Cleveland State University
Maxine Goodman Levin College of Urban Affairs

Prepared for:
NASA GLENN RESEARCH CENTER

Prepared by:
Iryna Lendel, Ph.D.
Sunjoo Park

The NASA Glenn Research Center:

An Economic Impact Study Fiscal Year 2011

June 2012

CENTER FOR ECONOMIC DEVELOPMENT

2121 Euclid Avenue | Cleveland, Ohio 44115
http://urban.csuohio.edu/economicdevelopment

Acknowledgements

The authors would like to thank Robert Sefcik, Traci Savage, Dr. Howard Ross, Ronald Alexander and Robert Romero–employees of the NASA Glenn Research Center—and Christopher Blake and Robert Bilbrey from Booz Allen Hamilton consulting firm for their contributions to this project. They provided management and coordination, data, and feedback on the report's content. This project is truly a result of collaborative teamwork.

The authors of this report also want to recognize the assistance of researchers within the Levin College, whose efforts were instrumental to the success of this project. Dr. Ziona Austrian, Director of the Center for Economic Development, offered suggestions throughout the duration of this project and comments on the draft report. Matthew Hrubey edited the report.

Table of Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

- The John H. Glenn Research Center is one of 10 National Aeronautics and Space Administration (NASA) Centers. NASA Glenn is located at Lewis Field, a 350-acre site adjacent to Cleveland Hopkins International Airport. Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $433 million has been invested in NASA Glenn's physical plant. The estimated replacement cost is approximately $2 billion. NASA Glenn also includes the 6,400-acre Plum Brook Station near Sandusky, Ohio, 50 miles west of Cleveland. It specializes in large-scale tests that would be hazardous within the confines of the main campus.

- During the study period, NASA Glenn held leadership roles critical to programs and projects in all of NASA's missions: Human Exploration & Operations, Science, Space Technology, and Aeronautics. Within the **Human Exploration & Operations** mission (human spaceflight to the International Space Station, Moon, and beyond), NASA Glenn provided oversight of the Service Module (SM) for the shuttle-replacement vehicle (Orion). The SM provides power, propulsion, and communications for Orion's Crew Module (CM), where the astronauts reside in flight. NASA Glenn also provided oversight of important elements of the CM project, including building test flight hardware, and supported the International Space Station's operation of the electrical power system. NASA Glenn's **Science** mission included management of the In-Space Propulsion Technology Program, the Radioisotope Power Systems, and the development of technologies associated with both programs. These technologies help develop new ways to power scientific spacecraft including the Advanced Stirling Convertor (ASC) for the Advanced Stirling Radioisotope Generator (ASRG). Through increased efficiency in the use of power-generating material, these systems will allow for a greater number of scientific missions. In **Space Technology**, NASA Glenn led the planning for seven technology areas, including cryogenic propellant storage and transfer, solar electric propulsion, nanotechnology, and energy storage systems. It also provided leadership of the new NASA Space Technology Research Fellowships, which sponsored 80 graduate students in aerospace technology. In **Aeronautics,** NASA Glenn enriched its aeronautics heritage by concentrating research and program management efforts on the principles of flight in any atmosphere at any speed and the enhancement of aviation safety. For the Fundamental Aeronautics Program, NASA Glenn provided technical project management leadership and conducted research. For the Aviation Safety Program, NASA Glenn provided technical project management leadership for three projects.

- The report structure is as follows: Sections A and B provide an introduction and background for this report. Section C is an economic overview of NASA Glenn, including information related to employment and occupations, employee residences, payroll, expenditures, awards to academia and other institutions, revenues, and taxes paid by NASA Glenn employees. Section D provides estimates of the economic impact generated by NASA Glenn for an eight-county Northeast Ohio region and the state of Ohio during FY 2011. This report is an update of several earlier studies in which NASA Glenn's economic impact on Northeast Ohio and Ohio was estimated.

ECONOMIC IMPACT GENERATED BY NASA GLENN RESEARCH CENTER SPENDING

- Economic impact is an analytical approach used to estimate the economic benefits generated by an entity for an affected region. This study uses an input-output (I-O) model to estimate the effect of NASA Glenn's spending on the target economies. This model measures economic impact in terms of growth in output (sales), value added (output less intermediary goods), number of new and supported jobs, the increase in household earnings, and additional tax revenues. The table below summarizes NASA Glenn's economic impact on Northeast Ohio and the state of Ohio during FY 2011.

Economic Impact	Northeast Ohio	State of Ohio
Output	$1,192.0 million	$1,331.5 million
Value Added	$666.1 million	$737.7 million
Employment	7,819 jobs	9,261 jobs
Labor Income	$504.0 million	$556.6 million
Taxes	$94.2 million	$110.1 million

- NASA Glenn's activities in Northeast Ohio in FY 2011, stimulated by $738.6 million in revenues originating primarily from outside the region, generated an increased demand in output (sales) for goods and services produced in the region (valued at $1,192 million). Value-added output increased by $666.1 million as a result of NASA Glenn's activities. In addition, 7,819 jobs were created and supported in the region, and households in Northeast Ohio saw labor income increase by $504 million. NASA Glenn operations also generated $94.2 million in local, state, and federal taxes.
- NASA Glenn's activities in Ohio in FY 2011, stimulated by $738.6 million in revenues originating primarily from outside the state, generated an increased demand in output (sales) for products and services produced across the state (valued at $1,331.5 million). Value-added output increased by $737.7 million as a result of NASA Glenn's activities. In addition, 9,261 jobs were created and supported in Ohio, and households across the state saw labor income increase by $556.6 million. NASA Glenn's activities also generated $110.1 million in local, state, and federal taxes.
- Industries deriving the most benefit from direct NASA Glenn spending included scientific research and development services, other professional and technical services, businesses and facilities support services, information services, power generation, and maintenance and repair construction.
- Industries deriving the most benefit from spending by NASA Glenn personnel and other workers were in line with typical consumer spending patterns. These industries included food services, real estate and rental services, hospitals and healthcare offices, insurance services, commercial banks, and miscellaneous retailers.

NASA GLENN RESEARCH CENTER: AN OVERVIEW

- In FY 2011, NASA Glenn had 1,711 civil service employees, its highest number of employees since FY 2007. From FY 2007 to FY 2009, NASA Glenn's total civil service employment decreased by 22 people and then started growing again, adding 61 employees by FY 2011. From FY 2010 to FY 2011, NASA Glenn added 53 more employees (3.2%). For the last 5 years, the NASA Glenn's civil employment grew by 39 employees or 2.3%. The number of on- or near-site contractors employed was 1,858 in FY 2011. NASA Glenn's on- or near-site employment grew by 6% between FY 2007 and FY 2011. Overall, total employment at NASA Glenn, including civil service employees and local contractors, increased by 4.1% between FY 2007 and FY 2011.

- NASA Glenn employs highly educated and highly skilled people. In FY 2011, 82% of NASA Glenn's employees held bachelor's degrees or higher, compared to 74% in FY 2007. Of all NASA Glenn employees in FY 2011, 18% held doctoral degrees, 35% had master's degrees, and 29% had bachelor's degrees.

- The largest occupational category in FY 2011 was scientists and engineers, which accounted for 65% of all civil service employees. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2007, from 60% (1,003 employees) to 65% (1,112 employees) in FY 2011. Between FY 2010 and FY 2011, NASA Glenn hired 34 scientists and engineers.

- Compensation for NASA Glenn's civil service employees totaled $226.8 million in FY 2011. Total compensation included both payroll ($180.5 million) and employee benefits ($46.3 million). Total payroll decreased by $1.85 million (-0.8%) between FY 2010 and FY 2011, after adjusting for inflation.[1] The average wage per civil service employee decreased by 5%, after adjusting for inflation, from $110,847 in FY 2010 to $105,469 in FY 2011.[2] Compared to FY 2007, total compensation grew 7.7%, including a salary increase of 5.8% and a growth in benefits of 15.7%. During the same time period, the average wage per NASA Glenn employee increased by 3.4%, after adjusting for inflation.

- In FY 2011, NASA Glenn allocated its $495.3 million in spending to vendors in 48 states, Washington, D.C., Puerto Rico, and 12 foreign countries. Compared to its total expenditure of $552.9 million in FY 2010, NASA Glenn reduced its expenditures by 10.4% in FY 2011 (in nominal dollars).

- In FY 2011, Ohio was the largest beneficiary of NASA Glenn's spending. Ohio received $312.8 million, accounting for 63.1% of NASA Glenn's total expenditures. Despite a $11.5 million decrease (in nominal dollars) compared to FY 2010, the share of NASA Glenn's expenditures in Ohio increased from 58.7% in FY 2010 to 63.1% in FY 2011.

- Besides Ohio, seven states (California, Maryland, Oklahoma, Tennessee, Connecticut, Massachusetts, and Virginia) received over $10 million, or at least 2% of NASA Glenn's total expenditures, during FY 2011. California and Maryland each received at least $22 million and ranked as the second- and third-largest beneficiaries of NASA Glenn's spending.

[1] Total nominal payroll increased by 2.3% ($5.2 million) between FY 2010 and FY 2011.
[2] The average wage per employee in nominal terms decreased by 1.8% between FY 2010 and FY 2011.

- In FY 2011, NASA Glenn increased its spending in foreign countries by 34% compared to FY 2010. Among foreign countries, the largest beneficiaries were Canada, Germany, Great Britain, and France.

- Spending in Ohio and Northeast Ohio had a significant economic impact on their respective regional economies. Northeast Ohio received $246.5 million in FY 2011, which accounted for 78.8% of NASA Glenn's total Ohio spending during that fiscal year ($312.8 million). NASA Glenn's largest expenditures were on scientific research and development, including equipment, supplies and materials, grants, and professional services.

- NASA Glenn provides funding to colleges, universities, and other nonprofit institutions in the form of contracts and grants for research and development assistance. In FY 2011, NASA Glenn awarded a total of $29.2 million to colleges and universities in 35 states and Puerto Rico. NASA Glenn reduced its academic funding by $7.8 million or 21% (in nominal dollars) from FY 2010 to FY 2011.

- Universities in five states—Maryland, Ohio, Oklahoma, California, and Massachusetts—received over $1 million in academic funding from NASA Glenn in FY 2011. The five states' awards accounted for 67.3% of NASA Glenn's total academic funding in FY 2011. The awards received by colleges and universities in Ohio ($5.9 million) alone accounted for 19.4% of NASA Glenn's total academic funding. The University of Toledo has been awarded the highest share of funding consistently over the last 5 years; it obtained $2 million in FY 2011, which accounted for 34.8% of total awards to colleges and universities in Ohio. The University of Akron received $1.4 million (23.5%) from NASA Glenn in FY 2011. NASA Glenn awarded Case Western Reserve University close to $0.8 million (13.7%) in FY 2011, making it the third-largest recipient in Ohio of academic awards from NASA Glenn.

- NASA Glenn's total revenue in FY 2011 reached $738.6 million. NASA Glenn's total revenue was lowest in FY 2007; it showed growth until FY 2009 and after a decline of 3.6% from FY 2009 to FY 2010, increased 0.3% in FY 2011. NASA Glenn's revenue increased 14% from FY 2007 to FY 2011 (in nominal dollars).

- NASA Glenn continues to be an important economic player both in Northeast Ohio and in the state of Ohio. NASA Glenn's employees are part of the knowledge-intensive labor force that generates wealth in the region and advances the nation.

A. INTRODUCTION

This report presents an analysis of the economic impact of the National Aeronautics and Space Administration's John H. Glenn Research Center (NASA Glenn) during its fiscal year (FY) 2011. It uses an input-output model, which reflects the buy-sell relationships among industries in a region, to estimate the effect of NASA Glenn's spending on the economies of both Northeast Ohio[3] and the state of Ohio. This model assesses economic impact in terms of growth in total output (sales), value added (output less intermediary goods),[4] household earnings, number of new jobs, and taxes.

The report also provides an overview of NASA Glenn and describes some of its R&D activities. It looks at changes in the typology of NASA Glenn's employees through their occupations, place of residence, and payroll.

The report further provides information on NASA Glenn's expenditures and revenues, awards to academic institutions, and taxes contributed by employees.

The analysis was conducted by the Center for Economic Development at Cleveland State University's Maxine Goodman Levin College of Urban Affairs. This FY 2011 report is an update to previous studies published in 1996, 2000, 2005, 2007, 2008, 2009, 2010 and 2011.[5]

[3] For purposes of this study, Northeast Ohio is defined as Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties.

[4] Output impact reflects the total value of all additional goods and services produced in the economy. For example, the output economic impact includes the total value of all professional scientific and technical services and all intermediary goods created to secure delivery of the scientific services. Value-added impact reflects the value of only additional output produced in the region, which is calculated as total sales less intermediary goods which are not sold as final products. For example, the value-added impact will account for the value of all professional scientific and technical services excluding intermediary goods produced to deliver these services. Such intermediary goods, among others, include research supplies, utilities, research services of intermediary steps of research, etc.

[5] All previous studies can be found on the Center for Economic Development's website: http://urban.csuohio.edu/economicdevelopment/publications/

B. NASA GLENN RESEARCH CENTER: BACKGROUND

The NASA Glenn Research Center, in partnership with U.S. industry, universities, and other government institutions, develops critical systems' technologies and capabilities that address national aerospace priorities. The Center is distinguished by a unique blend of aeronautics, space flight, and project management expertise and experience. Its work is focused on technological advances in space flight systems, aeropropulsion, space propulsion, power systems, nuclear systems, communications, and technology to enable human health in space. Its research, technology, and capability development efforts are vital to advancing exploration of our solar system and beyond while maintaining global leadership in aeronautics.

B.1. NASA GLENN TEST FACILITIES

NASA Glenn is located at Lewis Field, a 350-acre site adjacent to Cleveland Hopkins International Airport. Glenn's physical plant includes more than 150 buildings that contain a unique collection of world-class test facilities. Since the groundbreaking for the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (forerunner to NASA) on January 23, 1941, more than $433 million has been invested in Glenn's physical plant. The estimated replacement cost is approximately $2.0 billion.

NASA Glenn's Plum Brook Station, located in Sandusky, Ohio, is 50 miles west of Cleveland and the Lewis Field site, and hosts several large test facilities which use cryogenic fluids (gases frozen to their liquid state). Because working with large amounts of cryogenic fluids is inherently dangerous, the Plum Brook Station's 6,400 acres allow safe testing of spacecraft and hypersonic vehicles in realistic operating conditions from launch to planetary operations. Most of these capabilities are world-unique, including the largest space simulation chamber, the largest mechanical vibration table, the most powerful resonant acoustic test chamber, the largest electromagnetic test chamber, the largest space simulation chamber which can test in planetary dust, the largest liquid hydrogen-capable space simulation chamber, the only cold soak start/restart rocket engine test facility, and the only clean air hypersonic tunnel. Investments since 2000 total over $567 million. The total replacement cost of all Plum Brook Station facilities is approximately $4.0 billion.

B.2. NASA GLENN MISSION AREAS SUPPORTING NASA THEMES

During the period covered in this report, NASA Glenn held several leadership roles critical to programs and projects in all of NASA's missions: Human Exploration & Operations, Science, Space Technology and Aeronautics:

Human Exploration & Operations (human spaceflight to the International Space Station (ISS), Moon, and beyond)

- Applied human spaceflight engineering and technical capabilities to perform a variety of analysis and integration tasks to support development of the Space Launch System and the Orion Multi-Purpose Crew Vehicle.
- Contributed to the Human Research Program, which performs research and technology.

- Developed next-generation systems that support humans in space, and the Advanced Exploration Systems program, which is contributing technology advancements for future robotic and human spaceflight missions beyond low Earth orbit.
- Responsible for operation and exploration-related technology development and demonstrations as part of International Space Station research.
- Supported biological and physical research for the International Space Station.
- Oversaw the Service Module (SM) for the shuttle-replacement vehicle (Orion). The SM provides power, propulsion, and communications for Orion's Crew Module (CM), where the astronauts reside in flight.
- Oversaw important elements of the CM project, including building test flight hardware.
- Provided vital support on aspects of a new rocket that carries Orion to space, including power, thrust vector control, and shroud studies.
- Conducted environmental testing at Plum Brook Station of the entire Orion spacecraft.
- Managed several research and advanced technology development projects on the ISS and on Earth, in support of human exploration.
- Supported operation of the International Space Station electrical power system.
- Led the development of new, advanced communications technology, including the SCaN Testbed - a demonstration on the International Space Station of software-defined radios.

Science

- Managed the Radioisotope Power Systems Program and the development of associated technologies. Radioisotope Power Systems enable scientific missions where conventional power systems such as solar power or batteries are impractical. The Advanced Stirling Converter (ASC) and the Advanced Stirling Radioisotope Generator (ASRG) are examples of these technologies.
- Co-managed (with the Department of Energy) the Advanced Stirling Radioisotope Generator (ASRG) project, four times more efficient than previously flown systems.
- Managed the In-Space Propulsion Technology (ISPT) Program and development of its associated technologies, including propulsion systems (e.g. solar electric propulsion), spacecraft bus (e.g. power, extreme environments), sample return, and re-entry. System and mission studies were used to validate benefits.
- Developed new scientific instruments and mission concepts for planetary surfaces (e.g. Venus, Mars) and Earth science (e.g. fresh water).
- Supported NASA Headquarters with assessments and panel membership for Planetary Science, including high altitude balloon research, technology/tools coordination, and science advisory groups.

Space Technology

- The Manufacturing Innovation project includes innovation in rapid prototyping for low-cost manufacturing, including algorithm and software development for modeling and simulation to streamline the design to manufacturing pipeline.
- The Nanotechnology project consists of three project elements: (1) advanced nanotechnology research and applications to produce high-strength, low-weight composites for space structures, (2) advanced nanoelectronic development of minimally invasive, low-power sensors for structural health-monitoring applications, and (3) integration of composites and sensors into a panel for test and evaluation.
- The In-Space Propulsion project, performed by NASA Glenn, will focus on the component low-thrust and high-thrust

propulsion technology advances necessary for efficient transportation in deep space.

- The Nuclear Systems project will complete an integrated test using an advanced power conversion system and non-nuclear reactor simulator for in-space nuclear power and propulsion systems. Non-nuclear testing will validate the performance of integrated systems.
- The Solar Electric Propulsion project focuses on the development of point of departure concepts, in order to guide technology investments for future Solar Electric Propulsion (SEP) capability demonstrations.
- The Space Power Generation and Storage project will develop technologies and components to provide low-cost, abundant power for deep-space missions (and dual-use terrestrial applications), including high-efficiency solar cells, advanced batteries, and regenerative fuel cells.
- The Cryogenic Propellant Storage and Transfer (CPST) Technology Demonstration project is intended to minimize boil-off of cryogenic propellants on long duration missions, which is a critical capability needed to enable high-energy cryogenic propulsion stages, a key component of future human spaceflight architectures.

NASA Glenn also provided program leadership for the Agency's Space Technology Research Grants Program, whose purpose is to accelerate the development of push technologies (technology development not directed at a specific mission) to support future space science and exploration needs of NASA, other government agencies, and the commercial space sector. The program features a low TRL (1-3) technology portfolio for groundbreaking research in advanced space technology.

Aeronautics

NASA Glenn continued to improve upon its world-class aeronautics heritage by concentrating research and program management efforts on the mastery of the principles of flight in any atmosphere at any speed and the enhancement of aviation safety.

For the Fundamental Aeronautics Program, NASA Glenn provided technical project management leadership and conducted research for the following four projects:

- Hypersonics Project: Researched propulsion and high temperature materials, instrumentation and dynamic controls to enable very high speed flight, and reliable re-entry into planetary atmospheres.
- Supersonics Project: Provided scientific leadership in propulsion, combustion, and acoustic research to eliminate environmental (e.g., sonic boom) and performance barriers.
- Subsonics: Fixed Wing: Developed revolutionary technologies and aircraft concepts to achieve highly improved performance (e.g., fuel efficiency) while satisfying strict noise and emission constraints.
- Subsonics: Rotary Wing: Researched methods to improve civilian potential of rotary wing vehicles (helicopters) so that they can carry more payload to more distant destinations.

For the Aviation Safety Program, NASA Glenn provided technical project management leadership for the following three projects: Atmospheric Environment Safety Technologies (AEST) Project, System-wide Safety & Assurance Technologies (SSAT) Project, and Vehicle Systems Safety Technologies (VSST) Project. NASA Glenn played key roles in conducting long-term, cutting-edge research that will produce tools, methods, concepts, and technologies to improve the intrinsic safety features of aircraft engines. NASA Glenn also investigated sources of risk and provided technologies needed to help ensure safe flight in and around atmospheric hazards.

For the Integrated Systems Research Program (ISRP), NASA Glenn provided technical project management leadership and subject matter

expertise for two projects: the Environmental Responsible Aircraft (ERA) and the integration of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) projects. NASA Glenn is responsible for the ERA Propulsion Technology sub-element focused on developing and demonstrating, in collaboration with industry and other government agencies, integrated systems technologies that enable industry to meet the NASA goals for reduction in aircraft emissions, noise, and fuel burn for the 2025 time frame. The UAS in the NAS contributes capabilities that reduce the technical barriers related to the safety and operational challenges associated with enabling routine UAS to the NAS. NASA Glenn has primary responsibility for the communication technology sub-element for the UAS in the NAS.

C. NASA GLENN RESEARCH CENTER: ECONOMIC OVERVIEW

This section presents an economic overview of the NASA Glenn Research Center during FY 2011. Changes between FY 2007 and FY 2011 are described in terms of number of employees, occupational distribution, employees' places of residence, payroll, expenditures, academic awards, revenues, and income taxes paid by NASA Glenn employees.

C.1. EMPLOYMENT AND OCCUPATIONS

The labor force of NASA Glenn Research Center consists of two components: civil service employees and local contractors. Federal laboratories commonly contract employees to instill flexibility in their labor force. Contracted employees can be adjusted easily to meet the needs of research labs. The process of hiring civil servants is more lengthy and complex.

Table 1 shows the total number of NASA Glenn's civil service employees and the shares of four occupational categories between FY 2007 and FY 2011. In FY 2011, NASA Glenn had 1,711 civil service employees, which represents the employment peak of the study period. NASA Glenn's employment declined between FY 2007 and FY 2009 by 1.3%. Since FY 2009, however, NASA Glenn added 61 civil service employees, a 3.7% increase, through the end of FY 2011. Between FY 2010 and FY 2011 alone, NASA Glenn added 53 employees (3.2%). For the last 5 fiscal years, NASA Glenn's civil employment grew by 39 employees, or 2.3%.

Table 1. NASA Glenn Civil Service Employment Distribution by Occupational Category, FY 2007-FY 2011

Fiscal Year	Total	Occupational Category			
		Administrative Professional	Clerical	Scientists & Engineers	Technician
2007	1,672	21%	5%	60%	14%
2008	1,662	21%	5%	61%	12%
2009	1,650	20%	4%	63%	12%
2010	1,658	20%	4%	65%	11%
2011	1,711	20%	4%	65%	10%

Note: Table does not include local contractors.[6]

[6] A detailed listing of NASA Glenn's local contractors can be found at http://www.grc.nasa.gov/WWW/Procure/ContractorList/On-siteServiceContractorListing.htm

NASA Glenn's civil service employment consists of four occupational categories: administrative professional, clerical, scientists and engineers, and technicians. The occupational structure of NASA Glenn's employment has changed slightly during the study period.

The largest occupational category in FY 2011 was scientists and engineers, which accounted for 65% of the civil service employees in FY 2011. The share of scientists and engineers at NASA Glenn has gradually increased since FY 2007 from 60% (1,003 employees) to 65% (1,112 employees) in FY 2011. Between FY 2010 and FY 2011, NASA Glenn hired 34 scientists and engineers.

The administrative professional group was the second-largest occupational category at NASA Glenn. This category consistently accounted for about 20% of the total civil service employees during the study period. The technician group accounted for 10% of NASA Glenn employment in FY 2011. The share of technicians fell from 14% in FY 2007 to 10% in FY 2011, a decrease of 56 employees. The increase of scientists and engineers accompanied the loss of technicians over the years. The number of clerical staff accounted for 4% of the total civil service employees in FY 2011, a decrease of 19 (1%) since FY 2007.

NASA Glenn employs highly educated and highly skilled workers. In FY 2011, 82% of NASA Glenn's employees possessed bachelor's degrees or higher. Of all NASA Glenn employees, 18% held doctoral degrees, 35% held master's degrees, and 29% held bachelor's degrees. Compared to FY 2007, the level of educational attainment of NASA Glenn's civil service employees has increased. For instance, the share of employees holding bachelor's degrees or higher increased 8% between FY 2007 and FY 2011. The increasing share of highly educated employees between FY 2007 and FY 2011 reflects the increase in scientists and engineers hired by NASA Glenn during this period of time.

NASA Glenn employed 1,858 on- or near-site contractors in FY 2011. NASA Glenn's employment of local contractors grew by 6% between FY 2007 and FY 2011 (Table 2). However, between FY 2010 and FY 2011, the number of local contractors employed by NASA Glenn decreased 2.8%.

The total number of NASA Glenn employees, including both civil service employees and local contractors, was 3,569 in FY 2011. The total labor force remained unchanged from FY 2010 to FY 2011; NASA Glenn hired 53 civil service employees, while the number of on- or near-site local contractors decreased. Overall, NASA Glenn's total labor force increased 4.1% between FY 2007 and FY 2011.

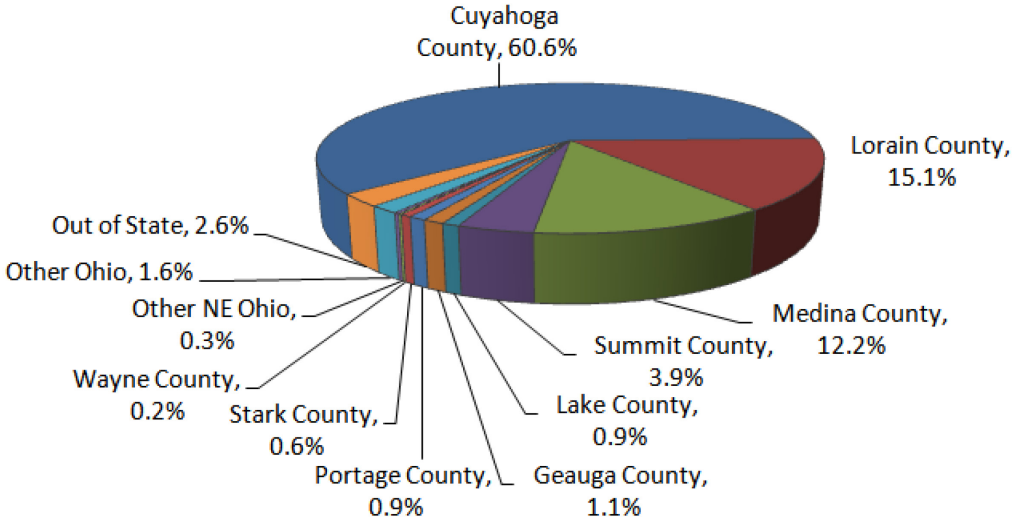
Table 2. NASA Glenn On- or Near-Site Contractors Employment, FY 2007-FY 2011

Fiscal Year	Employment of On- or Near-Site Contractors
2007	1,755
2008	1,874
2009	1,895
2010	1,912
2011	1,858

C.2. Place of Residence for Glenn Employees

NASA Glenn Research Center is located near Cleveland Hopkins International Airport in Cuyahoga County, Ohio. NASA Glenn also includes Plum Brook Station, located near Sandusky, Ohio, west of the main facility. Most civil service employees working at NASA Glenn live in Cuyahoga County or the other surrounding counties that comprise Northeast Ohio. Figure 1 shows the breakdown of employees' postal addresses by geographic region. During FY 2011, almost all of NASA Glenn's civil service employees (1,639 employees; 95.8%) resided in Northeast Ohio. Specifically, 60.6% of Glenn civil servants lived in Cuyahoga County, where NASA Glenn is located. A significant number of NASA Glenn employees also lived in Lorain (15.1%), Medina (12.2%), and Summit Counties (3.9%), as well as in counties southwest of Cuyahoga County. Of the total 1,711 workers employed by NASA Glenn in FY 2011, 27 employees (1.6%) lived in the remainder of Ohio and 44 employees (2.6%) possessed postal addresses located in other states. Compared to FY 2010, the number of NASA Glenn employees who resided outside Ohio increased by 10 (0.6%).

Figure 1. NASA Glenn Civil Service Employees by County of Residence, FY 2011



The places of residence of NASA Glenn's civil service employees are shown by occupation in Table 3. Cuyahoga County served as the place of residence for the highest share of employees in each occupational category. More than 60% of NASA Glenn's scientists and engineers, administrative professionals, and clerical employees lived in Cuyahoga County in FY 2011. Approximately 4% to 5% of NASA Glenn's scientists and engineers and administrative professionals have postal addresses outside of Northeast Ohio.

Table 3. NASA Glenn Civil Service Employees by Occupation and Place of Residence, FY 2011

Residence	Administrative Professional	Clerical	Scientists & Engineers	Technicians	Total
Northeast Ohio	**95.9%**	**98.1%**	**95.3%**	**98.8%**	**95.8%**
Cuyahoga County	60.3%	68.5%	61.5%	54.7%	60.6%
Lorain County	16.2%	18.5%	13.7%	19.5%	15.1%
Medina County	11.0%	9.3%	12.2%	17.0%	12.2%
Summit County	5.5%	0.0%	3.8%	1.9%	3.9%
Lake County	0.8%	1.9%	1.0%	1.3%	0.9%
Geauga County	0.8%	0.0%	1.1%	1.9%	1.1%
Portage County	0.5%	0.0%	1.0%	1.9%	0.9%
Stark County	0.3%	0.0%	0.6%	0.6%	0.6%
Wayne County	0.3%	0.0%	0.2%	0.0%	0.2%
Other NE Ohio	0.3%	0.0%	0.3%	1.3%	0.3%
Remainder of Ohio	**1.9%**	**1.9%**	**1.6%**	**1.3%**	**1.6%**
Out of State	**2.2%**	**0.0%**	**3.1%**	**0.0%**	**2.6%**

C.3. PAYROLL

Total compensation for NASA Glenn's civil service employees was $226.8 million in FY 2011. Total compensation in this report includes both payroll ($180.5 million) and employee benefits ($46.3 million). Total payroll decreased by $1.85 million (-0.8%) between FY 2010 and FY 2011, after adjusting for inflation.[7] The average wage per civil service employee decreased by 5% (after adjusting for inflation), from $110,847 in FY 2010 to $105,469 in FY 2011.[8]

Compared to FY 2007, in real dollars adjusted for inflation, total compensation in FY 2011 grew by 7.7%, including a salary increase of 5.8% and a growth in benefits of 15.7%. During the same time period, the average wage per civil service employee increased by 3.4%, from $102,027 in FY 2007 (inflation adjusted) to $105,469 in FY 2011.[9]

[7] Total nominal payroll increased by 2.3% ($5.2 million) between FY 2010 and FY 2011.

[8] The average wage per employee in nominal terms decreased by 1.8% between FY 2010 and FY 2011.

[9] In nominal dollars, the average employee wage rose from $94,045 in FY 2007 to $105,469 in FY 2011, an increase of 12.1%.

C.4. NASA GLENN EXPENDITURES, FY 2011

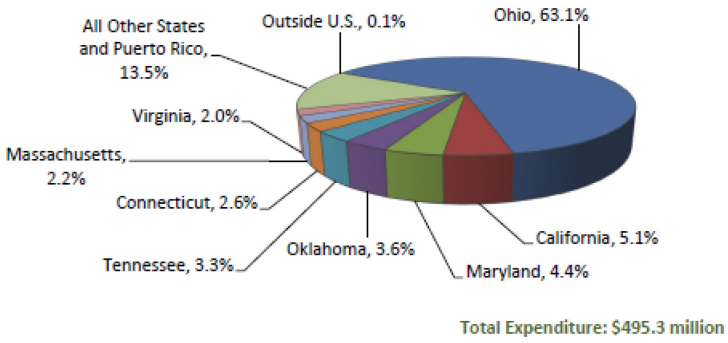
In FY 2011, NASA Glenn allocated its spending of $495.3 million to vendors in 48 states, Washington, D.C., Puerto Rico, and 12 foreign countries. Compared to its total expenditure of $552.9 million in FY 2010, NASA Glenn reduced its expenditures by 10.4% in FY 2011 (in nominal dollars).

Figure 2 shows the geographic distribution of NASA Glenn's spending in FY 2011. Ohio was the largest beneficiary of funds, receiving $312.8 million or 63.1% of NASA Glenn's total expenditures. Despite a $11.5 million decrease (in nominal dollars) compared to FY 2010, the share of NASA Glenn's expenditures in Ohio increased from 58.7% in FY 2010 to 63.1% in FY 2011. Of Ohio's total expenditures, Northeast Ohio received $246.5 million, which accounted for 78.8% of NASA Glenn's Ohio spending in FY 2011. Northeast Ohio also accounted for 49.8% of NASA Glenn's total spending in FY 2011.

Other states and Puerto Rico received $182.1 million in FY 2011 (36.8% of NASA Glenn's total spending). Besides Ohio, seven states (California, Maryland, Oklahoma, Tennessee, Connecticut, Massachusetts, and Virginia) each received over $10 million, or at least 2% of NASA Glenn's total expenditures, during FY 2011. California received $25.5 million and Maryland $22 million, making them the second- and third-largest beneficiaries of NASA Glenn's spending. Compared to FY 2010, however, NASA Glenn decreased its expenditures in Oklahoma by $35.4 million in FY 2011. Oklahoma ranked as the fourth-largest beneficiary of NASA Glenn's expenditures, despite sustaining a 66.6% loss of funding from NASA Glenn between FY 2010 and FY 2011. Meanwhile, NASA Glenn increased its spending in Tennessee by five times, from $3.2 million in FY 2010 to $16.3 million in FY 2011 countries. (See Appendix Table A.1. for more.)

In FY 2011, NASA Glenn increased its spending in foreign countries by 34% compared to FY 2010. Foreign countries received $0.4 million, accounting for 0.1% of NASA Glenn's total spending in FY 2011. The largest beneficiaries were Canada, Germany, Great Britain, and France, which together accounted for 98.5% of NASA Glenn's total spending in foreign countries. (See Appendix Table A.1. for more.)

Figure 2. NASA Glenn Spending in Select States, FY 2011



Note: Figures in nominal dollars.

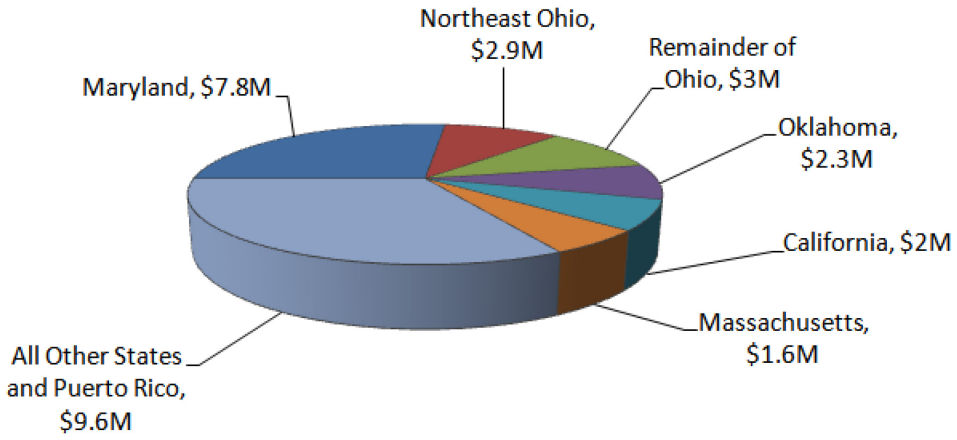
C.5. NASA Glenn Awards to Academic and Other Institutions

NASA Glenn Research Center awards funding to colleges, universities, and other nonprofit institutions in the form of R&D contracts and grants for assisting NASA in their research and development activities.

In FY 2011, NASA Glenn awarded $29.2 million to colleges and universities in 35 states and Puerto Rico. Compared to FY 2010, this represented a reduction of academic funding by NASA Glenn of $7.8 million (-21% in nominal dollars).

Figure 3 shows the distribution of funding awarded to colleges and universities with emphasis on select states. Universities in five states—Maryland, Ohio, Oklahoma, California, and Massachusetts—received over $1 million in funding from NASA Glenn in FY 2011. The academic funding awarded in these five states collectively accounted for 67.3% of the total in FY 2011. (See Appendix Table A.2. for more.)

Figure 3. NASA Glenn Awards to Colleges and Universities, FY 2011



Total Expediture: $29.2 million

Notes:
Figures in nominal dollars.
"Remainder of Ohio" refers to colleges and universities located outside the 8-county definition of Northeast Ohio used in this report.

Colleges and universities in Maryland received $7.8 million, which accounted for the largest share (26.7%) of NASA Glenn's academic awards in FY 2011. NASA Glenn's academic awards to Maryland decreased 17.4% (-$1.6 million) between FY 2010 and FY 2011.

Colleges and universities in Ohio received $5.9 million in academic funding from NASA Glenn, which accounted for 19.4% of all academic awards in FY 2011.

Within the state of Ohio, academic institutions in Northeast Ohio received $2.9 million in FY 2011. This accounted for both 9.9% of NASA Glenn's total academic awards and 49.2% of all academic grants received by Ohio colleges and universities. NASA Glenn increased its awards to the universities and colleges in Northeast Ohio by 15.6% ($0.4 million) compared to FY 2010.

In FY 2011, Oklahoma received $2.3 million, California received $2 million, and Massachusetts received $1.6 million in academic funding from NASA Glenn. (See Appendix Table A.2. for more.)

Table 4 shows the distribution of NASA Glenn awards to colleges and universities in Ohio from FY 2007 to FY 2011 (inflated to 2011 dollars). Total academic funding awarded in Ohio decreased by 47.6%, from $11 million in FY 2007 to $5.9 million in FY 2011. Between FY 2010 and FY 2011, NASA Glenn reduced its academic grants to Ohio universities and colleges by $1.6 million or 21% (adjusted to 2011 dollars).

University of Toledo and University of Akron each received more than $1 million from NASA Glenn in FY 2011. University of Toledo has been consistently awarded the highest share of funding from NASA Glenn over the last 5 years; it obtained $2 million in FY 2011, which accounted for 34.8% of total awards to colleges and universities in Ohio. University of Akron received $1.4 million (23.5%) from NASA Glenn in FY 2011.

In FY 2011, colleges and universities in Northeast Ohio received $2.9 million: University of Akron ($1.4 million), Case Western Reserve University ($0.8 million), and Cleveland State University ($0.7 million).

Table 4. NASA Glenn Educational Grants in Ohio by Academic Institution, FY 2007-FY 2011

OHIO COLLEGES & UNIVERSITIES	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2011 Share
University of Toledo	$4,053,273	$3,543,693	$2,664,727	$2,864,212	$2,037,240	34.80%
University of Akron	$582,985	$1,169,070	$1,282,916	$653,294	$1,376,131	23.51%
Case Western Reserve University	$2,363,689	$1,698,044	$837,437	$860,584	$799,690	13.66%
Cleveland State University	$1,732,901	$1,529,176	$749,724	$1,056,752	$705,925	12.06%
Ohio State University	$2,123,190	$1,885,807	$2,143,836	$1,499,532	$528,443	9.03%
Ohio University	$39,696	$56,889	$71,860	$200,807	$181,110	3.09%
University of Cincinnati	$190,048	$643,679	$509,023	$279,560	$174,581	2.98%
Wright State University	$48,008	$504	$33,956	$17,479	$32,784	0.56%
Kent State University	$2,500			$361	$18,499	0.32%
University of Dayton	$13,529		$50,463			
Bowling Green State University	$33,412		$29,617			
Cuyahoga Community College	$595	$37,376	$10,526			
John Carroll University	($10,782)					
TOTAL	**$11,173,043**	**$10,564,237**	**$8,384,085**	**$7,432,582**	**$5,854,403**	**100.00%**

Notes:
Table is sorted by FY 2011 column.
Data inflated to 2011 dollars.

C.6. NASA Glenn Revenues

NASA Glenn's total revenue in FY 2011 was $738.6 million. NASA Glenn's total revenue was lowest in FY 2007; it showed growth until FY 2009 and after a decline of 3.6% from FY 2009 to FY 2010, it increased 0.3% in FY 2011. NASA Glenn's revenue increased 14% from FY 2007 to FY 2011 (in nominal dollars).

Table 5 shows NASA Glenn's revenue by source from FY 2007 to FY 2011. NASA Glenn's revenue comes from two sources: NASA direct authority and reimbursable commitments. The share of revenue from NASA's direct authority accounted for close to 96% each year from FY 2007 to FY 2010, but dropped slightly to 94.4% in FY 2011. In FY 2011, Glenn received $696.9 million of revenue directly from NASA and an additional $41.7 million from reimbursable commitments.

NASA Glenn's revenue from sources other than NASA's direct authority increased by 35.8% ($11 million in nominal dollars) from FY 2010 to FY 2011. During FY 2011, the structure of reimbursable commitments included the Department of Defense (13.2%); other federal agencies (63.1%); and domestic, nonfederal entities (23.7%).

Table 5. NASA Glenn Revenues, FY 2007-FY 2011

Revenue Source	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
NASA Direct Authority	$626,910	$671,663	$731,026	$705,550	$696,917
Reimbursable Commitments	$20,172	$27,886	$32,606	$30,682	$41,680
Total FY Authority	**$647,082**	**$699,549**	**$763,632**	**$736,232**	**$738,597**
Revenue from NASA	**96.9%**	**96.0%**	**95.7%**	**95.8%**	**94.4%**

Note: Data in thousands of nominal dollars.

C.7. TAXES PAID BY NASA GLENN EMPLOYEES

Taxes paid directly to state and local governments by NASA Glenn employees play an important role in the regional economies of Northeast Ohio and the state of Ohio. The amount of taxes paid by NASA Glenn is determined by the total employment and payroll of employees whose workplaces are located on the NASA Glenn campus. Most NASA Glenn employees reside in the cities of Brook Park, Fairview Park, and Cleveland, which affects the distribution of income tax paid by Glenn employees.

Table 6 shows the amount of income taxes withheld from the paychecks of NASA Glenn employees and sent directly to state and local governments. These taxes exclude those paid by employees to local governments based on their place of residence. In FY 2011, the total amount of income tax paid by NASA Glenn's employees was $9.8 million. Compared to FY 2007, NASA Glenn employees paid $607,209 more in income taxes in FY 2011 (in nominal dollars).

The state of Ohio and the city of Brook Park were the two largest beneficiaries of the income taxes paid by NASA Glenn's employees. Together, they accounted for 99.6% of the total state and local income taxes paid in FY 2011. The state of Ohio's share of income tax in FY 2011 was 64.8% ($6.4 million). Over the past 5 years, NASA Glenn employees paid approximately $31 million to the state of Ohio. In FY 2011, the city of Brook Park received $3.4 million in income tax from NASA Glenn employees, a 4.8% increase compared to FY 2010.

NASA Glenn employees paid $26,097 in income tax to the city of Fairview Park in FY 2011. This represented an 84% decrease in income tax paid by NASA Glenn workers to the city of Fairview Park between FY 2010 and FY 2011. This shift in taxes occurred due to the relocation of civil servants from facilities in Fairview Park to the main campus in 2010. At the same time, income tax paid to the city of Cleveland remained very low, although the total increased more than five times between FY 2007 and FY 2011.

Table 6. Income Taxes Paid by NASA Glenn Employees

Year	City of Brook Park	City of Cleveland	City of Fairview Park	State of Ohio	Total
2007	$2,748,507	$2,362	$389,630	$6,097,704	**$9,238,203**
2008	$2,844,033	$6,910	$399,634	$6,189,703	**$9,440,279**
2009	$2,941,876	$9,174	$385,752	$6,098,786	**$9,435,588**
2010	$3,264,189	$11,465	$160,915	$6,346,527	**$9,783,096**
2011	$3,421,825	$12,755	$26,097	$6,384,735	**$9,845,412**

Note: Data in nominal dollars.

D. ECONOMIC IMPACT OF NASA GLENN

This section discusses the economic impact of NASA Glenn on Northeast Ohio[10] and the state of Ohio in FY 2011. Total impact is measured in terms of output (sales), employment, value added, household earnings, and taxes contributed to local, state, and federal governments. Each of these categories (except taxes) is estimated as the sum of four components: change in final demand, direct impact, indirect impact, and induced impact. NASA Glenn's total impact on Northeast Ohio and the state of Ohio are estimated separately.

D.1. METHODOLOGY

The estimation of economic impact in this study is based on the assumption that NASA Glenn came into existence at the beginning of FY 2011 and instantly generated a demand for goods and services needed for its operation. The increase in final demand reflects the investment into NASA Glenn and, therefore, into the Northeast Ohio and Ohio economies. The increase in demand from NASA's expenditures in the region generates an economic impact (on Northeast Ohio or Ohio) that can be quantified by including the change in final demand in a statistical model.[11] The effects of a change in final demand are traced throughout the Northeast Ohio or Ohio economies using an input-output model that reflects the buy-sell relationships among all industry sectors and the household sector.

In order for NASA Glenn to engage in research and development, other goods and services are needed as intermediate inputs and other purchases occur from income received by NASA Glenn employees. This leads to the generation of other components of economic impact: direct, indirect, and induced. Changes in final demand reflect initial first-round effects. The first-round effects consist of total spending by NASA Glenn, value added, household income (total payroll of NASA Glenn's employees), and employment (total employment of NASA Glenn in a given year). For the estimation in this report, FY 2011 is the target time period.

Direct impact refers to the initial value of goods and services, including labor, purchased by NASA Glenn to conduct its operations within Northeast Ohio or the state of Ohio.[12] Indirect impact measures the value of labor, capital, and other inputs of production needed to produce the goods and services required by NASA Glenn. Induced impact measures the change in spending by local households due to increased earnings by employees in local industries who produce goods and services for NASA Glenn and its suppliers.

Economic impact analysis takes into account inter-industry buy-sell relationships within the economy. These relationships largely determine how the economy responds to changes in economic activity. Input-output (I-O) models estimate inter-industry relationships in a county, region, state, or country level by measuring the distribution of inputs purchased and outputs sold by each industry and the household sector. Thus, by using I-O models, it is possible to estimate how the impact of one additional dollar or one additional job required for NASA Glenn to operate ripples through the target economies, creating additional expenditures and jobs. The economic multiplier measures

[10] For this analysis, Northeast Ohio is limited to the Akron and Cleveland metropolitan areas and includes Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit counties.

[11] Change in final demand is defined as the purchases of goods and services for NASA Glenn's final consumption.

[12] For NASA Glenn, it is a first-order indirect effect.

the extent of the ripple effect that an initial expenditure has on the local economy.[13] This study utilizes regional I-O multipliers from the IMPLAN Professional model.[14] Specifically, SAM multipliers are used to estimate the ripple effect that an initial expenditure made by NASA Glenn has on a local economy.[15]

Two factors need to be addressed when estimating economic impact: (1) purchases from companies located outside the study region need to be excluded, and (2) the share of revenues received from local sources needs to be considered. For this analysis, NASA Glenn's economic impact on the Northeast Ohio economy is generated only by purchases from companies located within Northeast Ohio. In the same vein, the economic impact on the state of Ohio is generated only by NASA Glenn purchases from companies located within Ohio. Therefore, when estimating the impact on Northeast Ohio, goods and services purchased from businesses and other entities located outside the eight-county region were excluded from the model. Likewise, when estimating the impact on the state of Ohio, all goods and services purchased from businesses and entities located outside the state were excluded from the model. Spending of employees residing outside the study regions was also excluded from the respective models. Regarding sources of revenues, all of NASA Glenn's revenues were received from non-local sources (federal sources) and, therefore, no further adjustments were required.

The economic impact is measured in terms of five variables: employment, labor income, value added, output, and taxes:

- Employment impact measures the number of additional jobs created in the region as a result of NASA Glenn expenditures.
- Labor income impact measures the additional household earnings created in the region due to NASA Glenn expenditures.
- Value-added impact measures the additional value-added output created in the region as a result of NASA Glenn expenditures. Value-added is calculated as output less the value of intermediary goods.[16]
- Output impact measures the additional value of goods and services produced in the region as a result of NASA Glenn expenditures.
- Tax impact measures the additional federal, state, and local tax revenues collected in the region as a result of NASA Glenn expenditures.

[13] For example, suppose that Company A reports sales of $1 million. From the revenues, the company pays its suppliers and workers, covers production costs, and takes a profit. Once the suppliers and employees receive their payments, they will spend a portion of their money in the local economy purchasing goods and services, while another portion of the monies will be spent outside the local economy (leakage). By evaluating the chain of local purchases that result from the initial infusion of $1 million, it is possible to estimate a regional economic multiplier.

[14] IMPLAN (IMpact analysis for PLANning) was originally developed by two federal agencies, the Department of Agriculture and the Department of the Interior, to assist in land and resource management planning. The model was later commercialized by the Minnesota IMPLAN Group, Inc. as a software package.

[15] IMPLAN type SAM (Social Accounting Matrices) multipliers are used in this study. SAM multipliers are based on information in a social account matrix that considers social security and income tax leakages, institutional savings, commuting, and inter-institutional transfers.

[16] Intermediary goods and services—such as energy, materials, and purchased services—are purchased for the production of other goods and services rather than for final consumption.

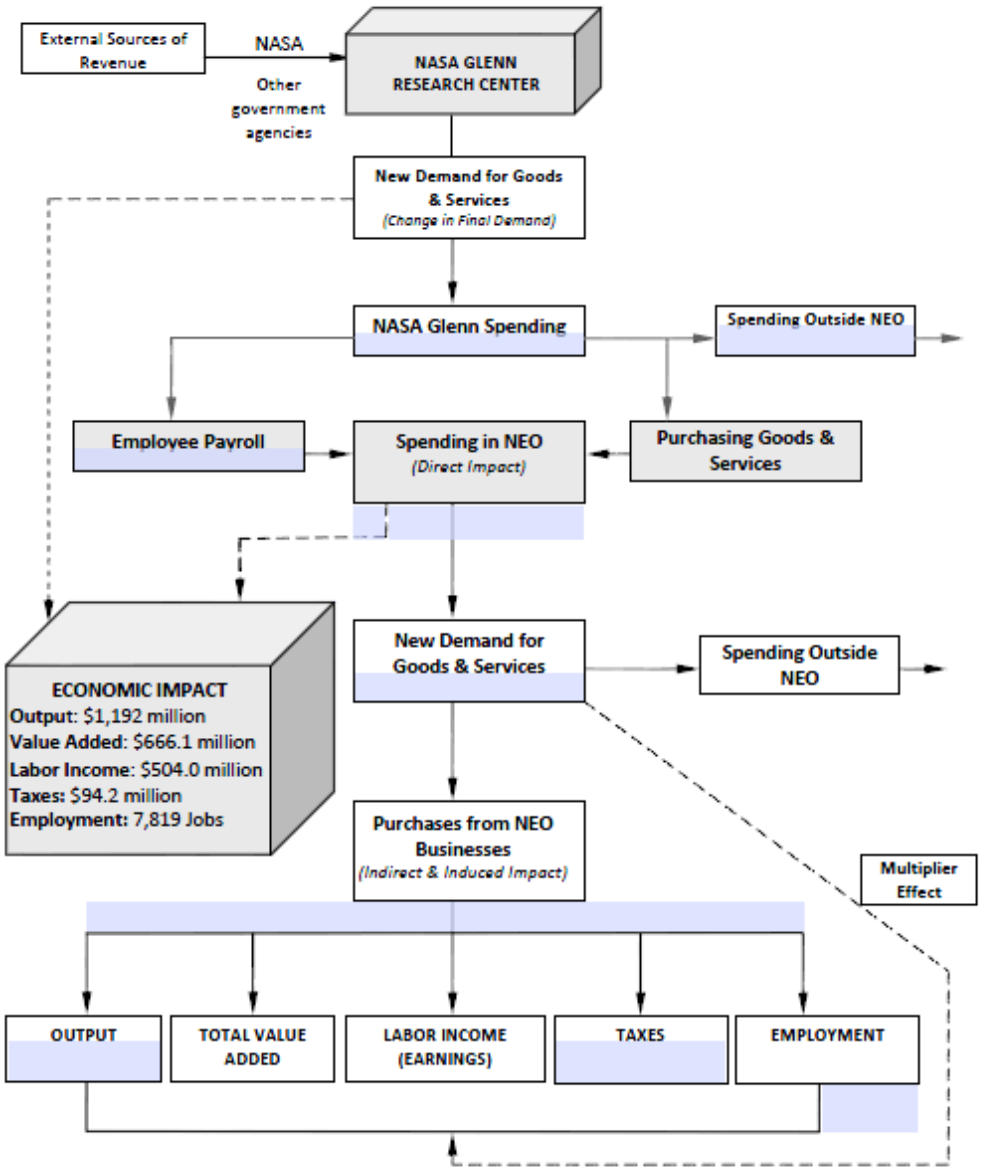
The employment, labor income, value-added, and output impacts are each a summation of four components: change in final demand, direct impact, indirect impact, and induced impact. [17]

Figure 4 illustrates the process by which NASA Glenn impacted the local economy through its spending in Northeast Ohio in FY 2011.

Through its attraction of federal dollars, NASA Glenn created new demand for goods and services (change in final demand). Some of this demand was generated for goods and services provided by vendors outside the Northeast Ohio, resulting in dollars leaking from the regional economy. However, the majority of goods and services were purchased locally.

[17] The summation of direct, indirect, and induced impacts across industries in the impact tables (Tables 7-14) may reflect rounding discrepancies created by multiple iterations of IMPLAN modeling.

Figure 4. Economic Impact of NASA Glenn Research Center on Northeast Ohio, FY 2011



D.2. Economic Impact on Northeast Ohio, FY 2011

This section describes the economic impact that NASA Glenn created on the Northeast Ohio economy in FY 2011. This analysis includes a detailed overview of the changes in output (sales), employment, labor income (earnings), value added, and taxes generated by NASA Glenn's activities.

D.2.1. Output Impact on Northeast Ohio, FY 2011

NASA Glenn's expenditures were divided into two groups of spending: (1) goods and services purchased from companies and institutions located in Northeast Ohio and (2) spending for goods and services from businesses and other entities located outside Northeast Ohio. The first group of spending creates an economic impact on the local economy. The second group is considered to be leakage from our economy. Local spending is then categorized by industry, based on an IMPLAN industry classification system that differentiates spending across 440 sectors. IMPLAN sectors are similar to the description of industries used in the North American Industry Classification System (NAICS), but do not completely correspond to the NAICS system. Table A.3., found in Appendix A, provides detailed NASA Glenn expenditures in Northeast Ohio by industry.

NASA Glenn's largest expenditures in FY 2011 were spent on scientific research and development services, including equipment, supplies and materials, grants, and professional services. The spending that takes place in Ohio and Northeast Ohio produces significant economic impact on the respective economies.

Table 7 presents the total output impact of NASA Glenn, which represents the sum of its change in final demand, direct impact, indirect impact, and induced impact. NASA Glenn's expenditures in Northeast Ohio represent the direct output impact. This impact includes all direct purchases made from industries in Northeast Ohio and the regional margin of purchases from the retail industry. Indirect impact is estimated by summing the contributions of individual industries that supply input materials and services to the producers of the goods and services consumed by NASA Glenn. Lastly, induced impact is estimated by summing the spending of workers employed at NASA Glenn and its suppliers as a result of the demand for products and services created by NASA Glenn.

Table 7. Output Impact Based on NASA Glenn Spending in Northeast Ohio, FY 2011

NASA Glenn Total Expenditures in Northeast Ohio: $447,094,081

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$105,443	$421,082	$526,525
Mining	$0	$507,115	$575,348	$1,082,463
Utilities	$12,683,154	$1,235,059	$5,965,905	$19,884,119
Construction	$31,935,942	$3,111,539	$2,398,147	$37,445,628
Manufacturing	$1,380,771	$4,288,983	$11,724,313	$17,394,067
Wholesale Trade	$287,714	$1,835,563	$17,596,735	$19,720,011
Retail Trade	$807,344	$1,054,523	$39,582,834	$41,444,701
Transportation & Warehousing	$15,554	$3,689,389	$8,247,873	$11,952,816
Information	$12,982,537	$5,705,716	$12,962,114	$31,650,367
Finance & Insurance	$0	$9,443,157	$58,666,111	$68,109,268
Real Estate & Rental	$347,745	$6,765,303	$69,324,630	$76,437,679
Professional - Scientific & Technical Svcs	$136,068,269	$17,597,065	$16,410,178	$170,075,512
Management of Companies	$0	$1,938,602	$3,315,516	$5,254,118
Administrative & Waste Services	$44,371,840	$10,938,472	$9,192,778	$64,503,090
Educational Services	$2,905,389	$30,825	$7,262,373	$10,198,588
Health & Social Services	$1,349,433	$53,789	$60,169,982	$61,573,204
Arts - Entertainment & Recreation	$335,558	$396,261	$4,665,977	$5,397,795
Accommodation & Food Services	$32,433	$2,242,301	$18,857,740	$21,132,474
Other Services	$0	$2,967,357	$18,290,438	$21,257,795
Government & Non-NAICs	$0	$1,852,085	$9,753,682	$11,605,767
TOTAL	**$245,503,683**	**$75,758,547**	**$375,383,756**	**$696,645,986**
Change in Final Demand	$495,339,907			
Direct Impact	$245,503,683			
Indirect Impact	$75,758,547			
Induced Impact	$375,383,756			
Total Output Impact	**$1,191,985,893**			

Notes:
For output impact, the change in final demand equals the spending by NASA Glenn within and outside Northeast Ohio, excluding wages and benefits.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

The total output impact of NASA Glenn on Northeast Ohio was $1.192 billion in FY 2011. NASA Glenn's $447.1 million worth of expenditures in Northeast Ohio resulted in an output (sales) change of $696.6 million across all industry sectors (Table 7). For example, NASA Glenn's spending affected a $170 million increase in total sales by all professional, scientific, and technical services industries and a $10.2 million increase in sales (direct, indirect, and induced impacts) by the educational services industry. Further, if NASA Glenn did not exist in Northeast Ohio, the regional economy would have a $76.4 million decrease in output within the real estate and rental industry. Thus, the impact of NASA Glenn's presence in the area is represented as the increase in output of affected industries in comparison to the hypothetical absence of NASA Glenn in Northeast Ohio.

Of the total output impact, 41.6% ($495.3 million) is accounted for by the change in final demand that consists of resources NASA Glenn's operations bring into Northeast Ohio from outside the region. Approximately $245.5 million (20.6%) of the total output impact is a result of direct spending by NASA Glenn for goods and services purchased within Northeast Ohio. The remaining output impact of $451.1 million (37.8%) is due to the indirect and induced components as NASA Glenn purchases from first-round suppliers ripple through the economy.

A detailed analysis of the IMPLAN model's results indicates that the $696.7 million change in output (sales) can be divided into three broad categories: NASA Glenn-driven industries, consumer-driven industries, and other industries. NASA Glenn-driven industries are industries that increase sales, employment, and earnings primarily, but not exclusively, due to NASA Glenn's spending. Among these industries are utilities, construction, information, professional and scientific services, administrative and support services, and education. The total increase in output for these industries in FY 2011 was $333.8 million or 47.9% of NASA Glenn's total impact on Northeast Ohio.

The consumer-driven industries are those that increase sales, employment, and earnings primarily due to spending by NASA Glenn employees and other workers who produce goods and services for NASA Glenn and their suppliers. These industries include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.[18] The total increase in output for these industries in FY 2011 was $295.4 million or 42.4% of the total impact.

Other industries are those that are driven by both NASA Glenn and consumer spending, but their impact is split between NASA Glenn and other businesses in the region. They include manufacturing, government enterprises, agriculture, mining, wholesale trade, and transportation and warehousing. The total increase in output for these industries in FY 2011 was $67.5 million or 9.7% of the total impact.

The output distributions for select NASA Glenn-driven industries and consumer-driven industries are shown in Figure 5 and Figure 6, respectively. The industries presented in Figure 5 had additional sales of at least $10 million in FY 2011. The

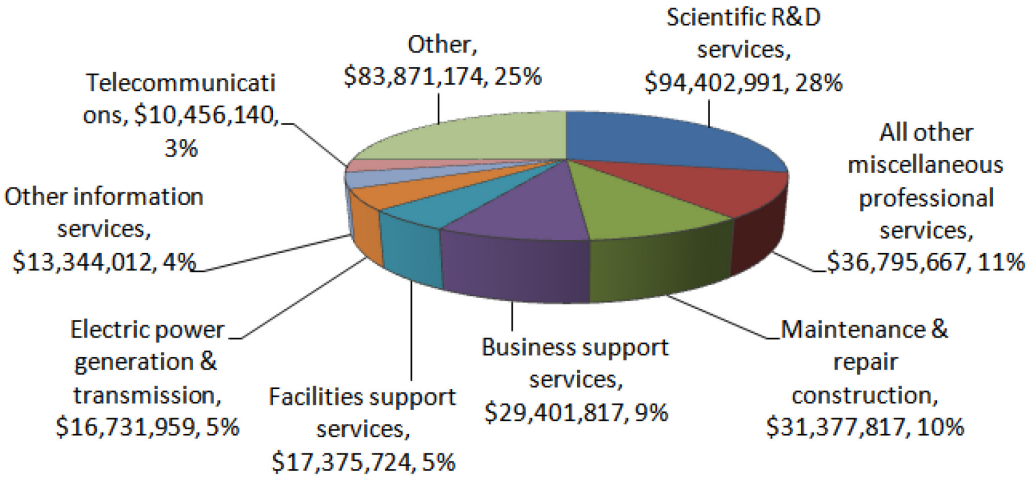
[18] An *owner-occupied dwelling* is a special industry sector developed by the Bureau of Economic Analysis. It estimates what owner/occupants would pay in rent if they rented rather than owned their homes. This sector creates an industry out of owning a home. Its sole product (or output) is ownership, purchased entirely by personal consumption expenditures. Owner-occupied dwellings capture the expenses of home ownership such as repair and maintenance construction, various closing costs, and other expenditures related to the upkeep of the space in the same way expenses are captured for rental properties.

industries presented in Figure 6 had additional sales of at least $12 million in FY 2011.

The scientific research and development industry generated the largest output impact; it increased by $94.4 million in FY 2011 due to NASA Glenn's operations (Figure 5). This amount is the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on research services. The increase of $94.4 million accounted for 28% of the $333.8 million increase in output for all NASA Glenn-driven industries. Other industries shown in Figure 5 can be interpreted similarly.

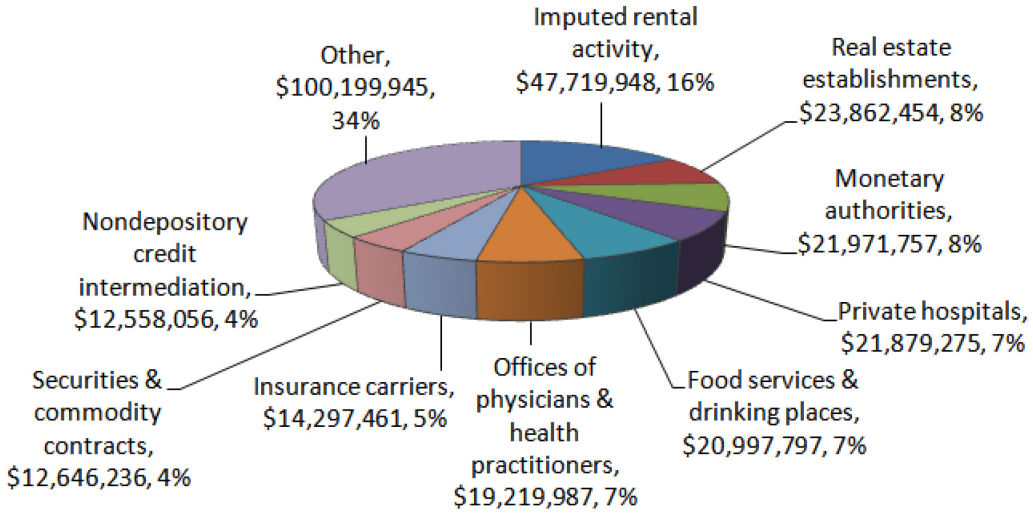
Figure 6 presents consumer-driven industries of the economy that saw large increases in sales. The imputed rental activity industry generated the largest output impact; it increased by $47.7 million in FY 2011 due to NASA Glenn's operations. This amount is the summation of the direct, indirect, and induced impacts generated primarily by NASA Glenn employees and other workers for rental activities. The increase of $47.7 million accounted for 16% of the $295.4 million increase in output for all industries within the consumer-driven sector. Other industries shown in Figure 6 can be interpreted similarly.

Figure 5. Increase in Sales for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2011



Total: $333.8 million

Figure 6. Increase in Sales for Select Consumer-Driven Industries in Northeast Ohio, FY 2011



Total: $295.4 million

D.2.2. Employment Impact on Northeast Ohio, FY 2011

NASA Glenn's operation in Northeast Ohio affected job creation beyond NASA Glenn's hiring of its own employees (change in final demand). NASA Glenn's spending triggered increased employment in industries from which it purchased goods and services (direct impact) and employment in industries that provided inputs into the production of those goods (indirect impact). In addition, money spent by employees of NASA Glenn and of businesses in the supply chain to NASA Glenn created jobs in a variety of other industries (induced impact). The total employment impact equals the sum of NASA Glenn's full-time equivalent (FTE) employment, direct impact, indirect impact, and induced impact. Table 8 shows the number of jobs created by industry sector.

Table 8. Employment Impact Based on NASA Glenn Spending in Northeast Ohio, FY 2011

NASA Glenn Expenditures in Northeast Ohio: $447,094,081

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	0	3	6	8
Mining	0	3	4	7
Utilities	25	2	10	38
Construction	313	27	24	365
Manufacturing	6	14	29	49
Wholesale Trade	2	12	112	125
Retail Trade	46	17	672	735
Transportation & Warehousing	0	30	68	99
Information	72	19	47	139
Finance & Insurance	0	43	301	344
Real Estate & Rental	1	46	176	224
Professional - Scientific & Technical Services	934	142	137	1,214
Management of Companies	0	10	18	28
Administrative & Waste Services	628	206	165	1,000
Educational Services	35	1	117	153
Health & Social Services	12	0	668	681
Arts - Entertainment & Recreation	3	8	89	100
Accommodation & Food Services	1	44	372	417
Other Services	0	32	288	321
Government & Non-NAICs	0	12	49	61
TOTAL	**2,080**	**673**	**3,355**	**6,108**
Change in Final Demand	1,711			
Direct Impact	2,080			
Indirect Impact	673			
Induced Impact	3,355			
Total Employment Impact	**7,819**			

Notes:
For employment impact, the change in final demand equals the number of full-time equivalent (FTE) employees working for NASA Glenn.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

The total employment impact of NASA Glenn on the Northeast Ohio economy in FY 2011 was 7,819 jobs. Of these 7,819 jobs, 1,711 (21.9%) were directly employed at NASA Glenn. As a result of Glenn's direct spending on goods and services, an additional 2,080 jobs (26.6%) were created in the region. The remaining employment impact, 4,028 jobs (51.5%), was in the form of indirect and induced impacts as NASA Glenn spending rippled through the regional economy.

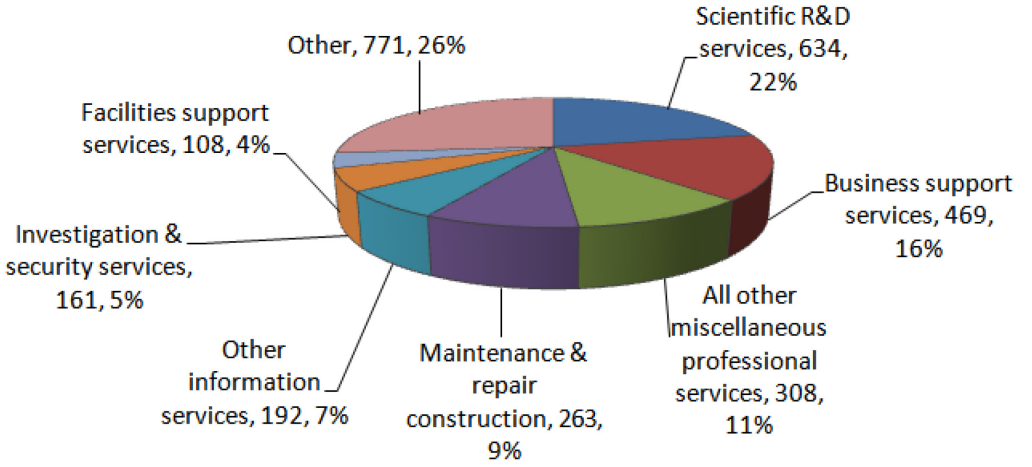
Of the 6,108 jobs created in Northeast Ohio due to the direct, indirect, and induced impacts, 2,908 (47.6%) were in NASA Glenn-driven industries, 2,822 (46.2%) were in consumer-driven industries, and 378 (6.2%) fell under the category of other industries.[19] The job distribution for select NASA Glenn-driven industries is shown in Figure 7. The job distribution for select consumer-driven industries is shown in Figure 8. The industries presented in Figures 7 and 8 are the leading industries in terms of most increased employment (minimum of 100 and 90 employees per industry, respectively).

The scientific research and development industry generated the highest number of additional jobs. Companies engaged in scientific R&D (professional, scientific, and technical services sector) saw an increase of 634 jobs in FY 2011 due to NASA Glenn's operation (Figure 7). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's spending on R&D contractors in Northeast Ohio. The 634 jobs accounted for 22% of the 2,908 jobs that were created in all industries within the NASA Glenn-driven ones.

The food services and drinking places industry saw an increase of 416 jobs in FY 2011 because of NASA Glenn's spending (Figure 8). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily by NASA Glenn employees and other workers buying food and going to restaurants in Northeast Ohio. The 416 jobs accounted for 15% of the 2,822 jobs that were created in all consumer-driven industries.

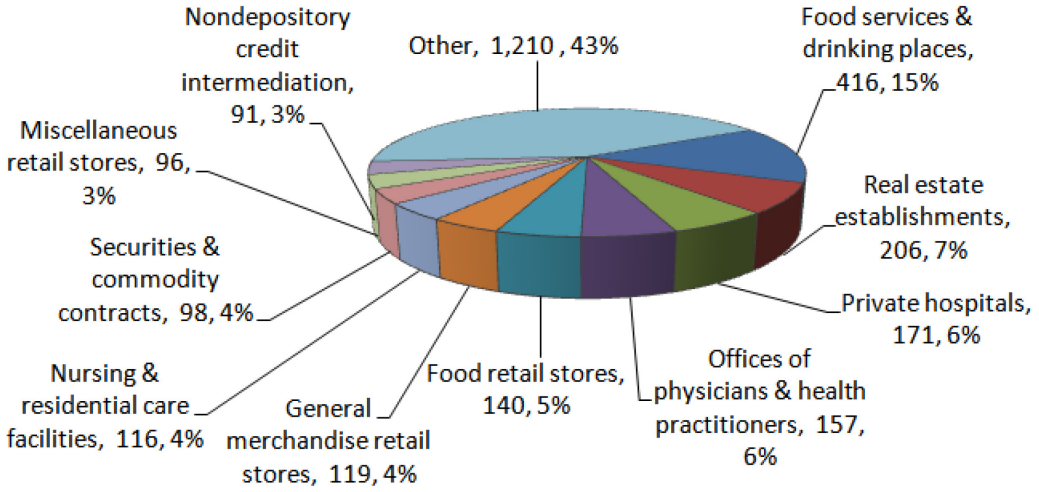
[19] NASA Glenn-driven industries include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven industries include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 7. Increase in Jobs for Select NASA Glenn-Driven Industries in Northeast Ohio, FY 2011



Total: 2,908 jobs

Figure 8. Increase in Jobs for Select Consumer-Driven Industries in Northeast Ohio, FY 2011



Total: 2,822 jobs

D.2.3. Labor Income Impact on Northeast Ohio, FY 2011

Labor income impact is the estimated total change in earnings paid to local households due to spending by NASA Glenn for goods and services purchased in Northeast Ohio. Money paid to employees of companies and other suppliers of goods and services to NASA Glenn represent the direct earnings impact. Indirect impact is estimated by summing the money paid to people working for companies that provide inputs to the producers of goods and services ultimately consumed by NASA Glenn.

Induced impact represents money paid to workers in all industries who are employed as a result of purchases by households whose income is affected by the demand for products and services created by NASA Glenn. The total earnings impact includes the wages and benefits received by NASA Glenn employees (change in final demand) and the direct, indirect, and induced impacts. Table 9 shows the earnings impact by industry sector.

Table 9. Labor Income Impact Based on NASA Glenn Spending in Northeast Ohio, FY 2011

NASA Glenn Expenditures in Northeast Ohio: $447,094,081

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$48,237	$209,860	$258,097
Mining	$0	$156,695	$230,674	$387,369
Utilities	$2,599,192	$227,097	$1,107,250	$3,933,539
Construction	$13,136,452	$1,227,620	$982,892	$15,346,964
Manufacturing	$384,086	$947,971	$1,809,014	$3,141,071
Wholesale Trade	$116,473	$857,565	$8,221,094	$9,195,131
Retail Trade	$728,573	$500,121	$18,393,991	$19,622,685
Transportation & Warehousing	$7,717	$1,561,339	$3,475,600	$5,044,657
Information	$3,355,689	$1,200,795	$2,688,096	$7,244,580
Finance & Insurance	$0	$2,588,472	$16,932,478	$19,520,950
Real Estate & Rental	$100,271	$997,333	$3,302,443	$4,400,047
Professional - Scientific & Technical Svcs	$67,676,364	$10,319,936	$9,574,282	$87,570,582
Management of Companies	$0	$1,044,780	$1,786,847	$2,831,626
Administrative & Waste Services	$26,690,003	$6,131,932	$5,010,017	$37,831,952
Educational Services	$1,675,575	$16,973	$4,161,984	$5,854,532
Health & Social Services	$592,856	$23,312	$33,416,709	$34,032,876
Arts - Entertainment & Recreation	$121,593	$187,485	$2,031,591	$2,340,669
Accommodation & Food Services	$11,684	$757,696	$6,377,988	$7,147,367
Other Services	$0	$1,355,945	$8,621,229	$9,977,175
Government & Non-NAICs	$0	$939,017	$3,525,164	$4,464,181
TOTAL	**$117,196,527**	**$31,090,320**	**$131,859,202**	**$280,146,049**
Change in Final Demand	$223,804,425			
Direct Impact	$117,196,527			
Indirect Impact	$31,090,320			
Induced Impact	$131,859,202			
Total Labor Income Impact	$503,950,474			

Notes:
Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy.
For labor income impact, the change in final demand equals the wages and benefits paid to NASA Glenn employees.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

Total labor income in Northeast Ohio increased by $504 million as a result of NASA Glenn's spending on goods and services in FY 2011. Of the $504 million, $223.8 million (44.4%) was the wages and benefits paid directly to NASA Glenn employees (i.e., change in final demand). Of the total impact, $117.2 million (23.2%) represented direct impact, or the money paid to employees of companies in Northeast Ohio that supply goods and services to NASA Glenn. The remaining earnings impact (indirect and induced components) was estimated at $163 million (32.4%) and occurred as the effects of NASA Glenn's spending rippled through the Northeast Ohio economy.

Of the $280.2 million increase in labor income generated across Northeast Ohio due to the direct, indirect, and induced impacts, $157.8 million (56.3%) was reported in NASA Glenn-driven industries, $97.0 million (34.6%) was generated in consumer-driven industries, and $25.4 million (9.1%) was reported in other industries.[20]

The labor income distribution for select NASA Glenn-driven industries is shown in Figure 9.

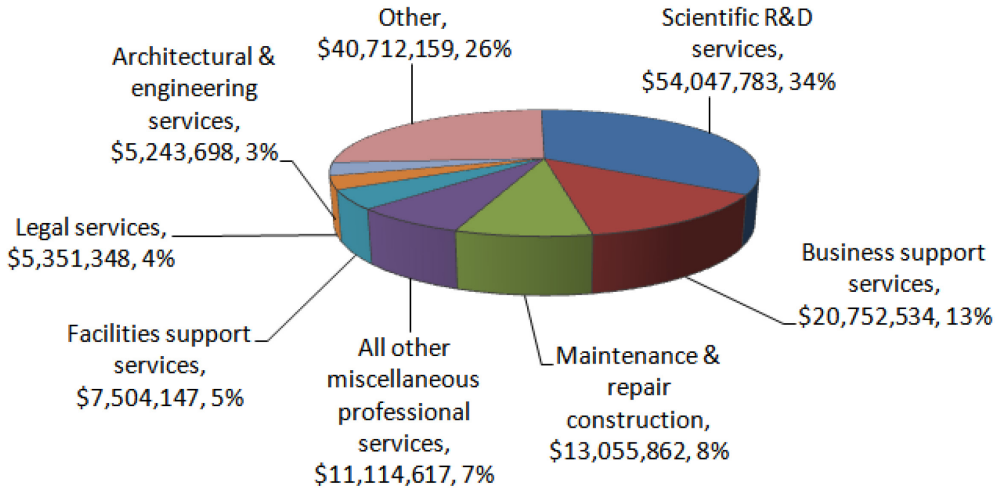
The labor income distribution for select consumer-driven industries is shown in Figure 10. The select industries shown in Figures 9 and 10 each added over $5 million and $3 million, respectively.

In the NASA Glenn-driven industries, people who were engaged in business support services saw their household earnings increase by $20.8 million in FY 2011 (Figure 9). These earnings are the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn using business support services in Northeast Ohio. The $20.8 million accounted for 13% of the $157.8 million increase in labor income reported by all the NASA Glenn-driven industries.

Doctors and other employees working in the offices of physicians and health practitioners industry saw their household earnings increase by $12 million in FY 2011 (Figure 10). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending for doctors' services. The $12 million accounted for 12% of the $97 million labor income increase that occurred in all the consumer-driven industries.

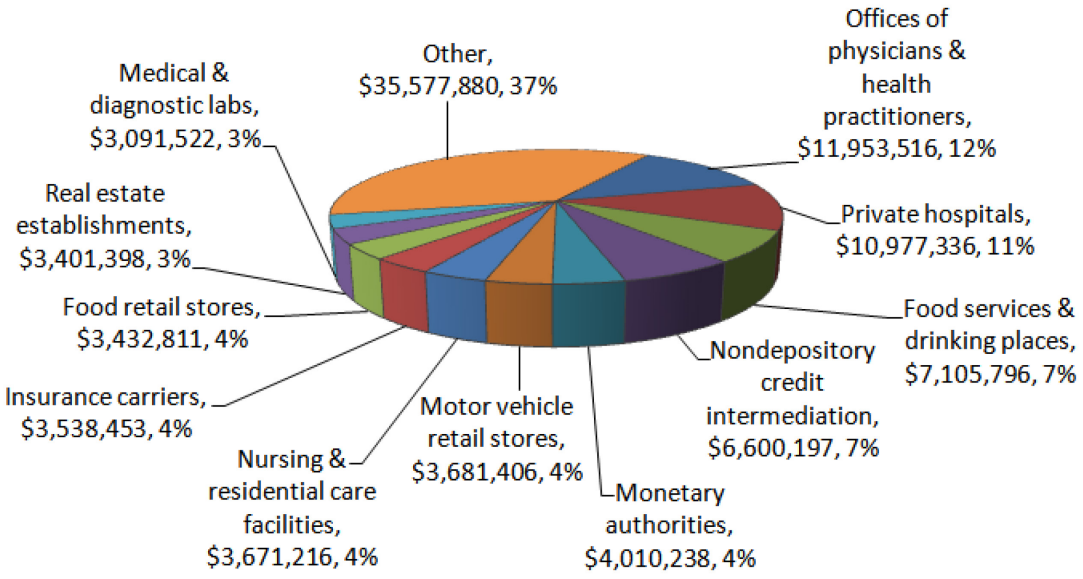
[20] See section D.2.1. Output Impact on Northeast Ohio for definitions of Glenn-driven, consumer-driven, and other industries.

Figure 9. Increase in Labor Income for NASA Glenn-Driven Industries in Northeast Ohio, FY 2011



Total: $157.8 million

Figure 10. Increase in Labor Income for Consumer-Driven Industries in Northeast Ohio, FY 2011



Total: $97 million

D.2.4. Value-Added Impact on Northeast Ohio, FY 2011

The total value-added impact[21] in Northeast Ohio was $666.1 million, which resulted from NASA Glenn's regional spending on goods and services. NASA Glenn's spending affected a $442.3 million increase in sales (direct, indirect, and induced impacts) by all industries, excluding intermediary goods and services. The wages and benefits received by NASA Glenn employees, $223.8 million in FY 2011, constituted the change in final demand for value added. The sales from companies and other suppliers of goods and services to NASA Glenn, excluding the value of intermediary goods and services, represented the direct value-added impact.

Indirect impact was estimated by summing the sales of companies that provide inputs to the producers of goods and services ultimately consumed by NASA Glenn, excluding the value of intermediary goods and services. Induced impact represented sales, excluding intermediary goods and services, in all industries that produced products for households whose income was affected by the demand for products and services created by NASA Glenn. The total value-added impact was found by adding the direct, indirect, and induced impacts to the wages and benefits received by NASA Glenn employees (change in final demand). Table 10 shows the value-added impact by industry sector.

[21] Value added measures the economic impact of all goods and services produced in Northeast Ohio because of the operation of NASA Glenn, excluding intermediary goods which are goods used in the production of other goods and not for final consumption.

Table 10. Value-Added Impact Based on NASA Glenn Spending in Northeast Ohio, FY 2011

NASA Glenn Expenditures in Northeast Ohio: $447,094,081

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$51,176	$207,879	$259,055
Mining	$0	$328,807	$401,154	$729,961
Utilities	$10,537,526	$882,692	$4,263,455	$15,683,673
Construction	$15,759,689	$1,465,818	$1,178,261	$18,403,767
Manufacturing	$552,780	$1,544,500	$3,277,009	$5,374,289
Wholesale Trade	$202,488	$1,490,869	$14,292,306	$15,985,663
Retail Trade	$1,138,989	$695,327	$26,258,776	$28,093,091
Transportation & Warehousing	$9,561	$2,214,027	$4,875,895	$7,099,483
Information	$10,657,436	$2,997,917	$6,909,518	$20,564,871
Finance & Insurance	$0	$4,714,766	$29,123,263	$33,838,029
Real Estate & Rental	$191,569	$5,564,709	$58,837,491	$64,593,768
Professional - Scientific & Technical Svcs	$90,043,777	$12,622,071	$12,382,184	$115,048,032
Management of Companies	$0	$1,207,853	$2,065,745	$3,273,598
Administrative & Waste Services	$29,448,117	$7,046,214	$5,897,083	$42,391,414
Educational Services	$1,709,997	$16,838	$3,793,479	$5,520,315
Health & Social Services	$734,489	$28,488	$36,036,556	$36,799,533
Arts - Entertainment & Recreation	$203,946	$226,582	$2,766,821	$3,197,350
Accommodation & Food Services	$17,948	$1,166,388	$9,805,475	$10,989,811
Other Services	$0	$1,565,914	$9,102,065	$10,667,978
Government & Non-NAICs	$0	$824,750	$2,969,804	$3,794,555
TOTAL	**$161,208,310**	**$46,655,708**	**$234,444,220**	**$442,308,238**
Change in Final Demand	$223,804,425			
Direct Impact	$161,208,310			
Indirect Impact	$46,655,708			
Induced Impact	$234,444,220			
Total Value-Added Impact	**$666,112,663**			

Notes:
For value-added impact, the change in final demand equals the wages and benefits paid to NASA Glenn employees.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns

Total value added in Northeast Ohio increased by $666.1 million in FY 2011 as a result of NASA Glenn's spending on goods and services. Of this total amount, $223.8 million (33.6%) was the wages and benefits paid to NASA Glenn employees (change in final demand). Another $161.2 million (24.2%) represented the value of goods and services, less intermediary goods, companies in Northeast Ohio supply to NASA Glenn (i.e., direct impact). The remaining value-added impact (indirect and induced components) was estimated at $281.1 million (42.2%). It occurred as a result of NASA Glenn's spending rippling through the Northeast Ohio economy.

Of the $442.3 million increase in value added generated across Northeast Ohio due to the direct, indirect, and induced impacts, $217.6 million (49.2%) was reported in NASA Glenn-driven industries, $188.2 (42.5%) was generated in consumer-driven industries, and $35.5 million (8.3%) was reported in other industries.[22]

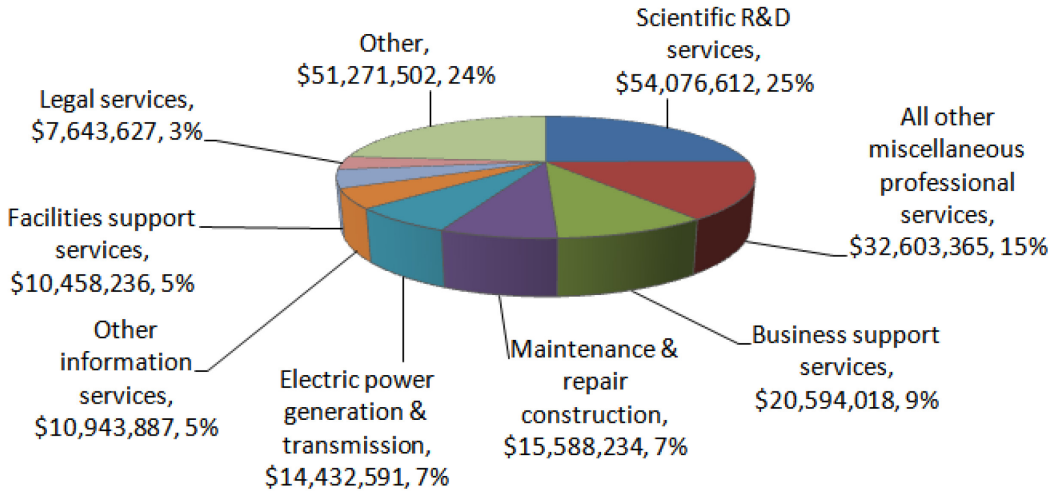
The value-added distribution for select NASA Glenn-driven industries is shown in Figure 11. The value-added distribution for select consumer-driven industries is shown in Figure 12. The select industries shown in Figures 11 and 12 each added over $7 million.

Persons engaged in the maintenance and repair construction industry saw their industry's value added increase by $15.6 million in FY 2011 (Figure 11). This increase in value added is a result of the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn using miscellaneous professional services in Northeast Ohio. The $15.6 million accounted for 7% of the $217.6 million value-added increase that was reported by all NASA Glenn-driven industries.

People working at private hospitals saw their household earnings increase by $11.9 million in FY 2011 (Figure 12). These earnings are the summation of the direct, indirect, and induced impacts generated by consumer spending at offices of local physicians and health practitioners. The $11.9 million accounted for 6% of the $188.2 million value-added increase that occurred in all consumer-driven industries.

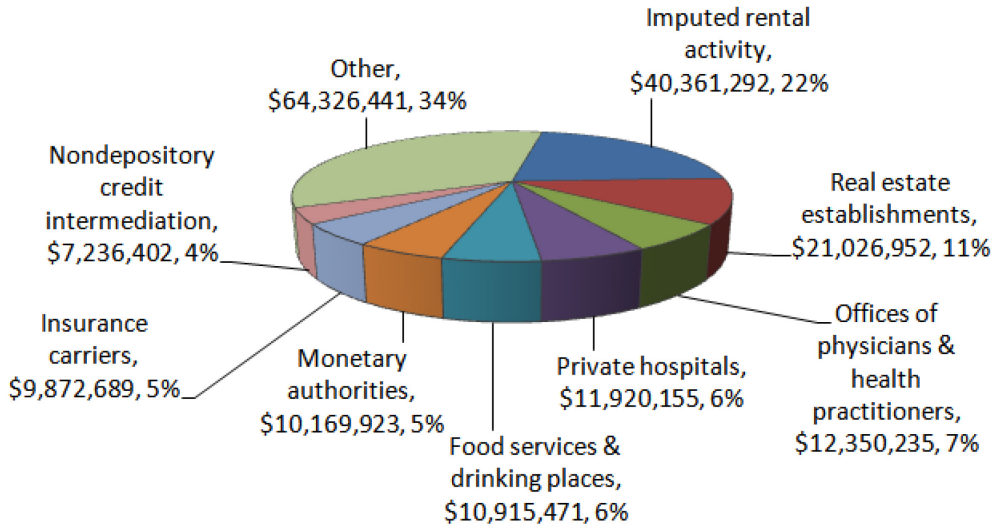
[22] See section D.2.1. Output Impact on Northeast Ohio for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 11. Increase in Value Added for NASA Glenn-Driven Industries in Northeast Ohio, FY 2011



Total: $217.6 million

Figure 12. Increase in Value Added for Consumer-Driven Industries in Northeast Ohio, FY 2011



Total: $188.2 million

D.2.5. Tax Impact on Northeast Ohio, FY 2011

NASA Glenn's operation generated a total of $94.2 million in tax revenues in FY 2011. Of that, local governments in Northeast Ohio and the state of Ohio benefited from increased tax revenues of $36.1 million, and federal tax revenues increased by $58.1 million in FY 2011.

D.2.6. FY 2011 Northeast Ohio Impact Summary

Economic activity conducted by NASA Glenn generated the following impact on Northeast Ohio (adjusted to 2011 dollars):

- Total Output Impact: $1,192.0 M
- Total Employment Impact: 7,819 jobs
- Total Labor Income Impact: $504.0 M
- Total Value-Added Impact: $666.1 M
- Total Tax Impact: $94.2 M

The economic impact presented here reflects the benefits of NASA Glenn's total expenditures of $447.1 million spent in Northeast Ohio in FY 2011. Excluding expenditures on households ($220.6 million), more than 60% ($136.1 million) of NASA Glenn's expenditures were allocated to professional, scientific and technical services; 20% ($44.4 million) was spent on administrative and support services; and 14.1% ($31.9 million) was spent on construction. These three sectors together accounted for 94.1% of all NASA Glenn's FY 2011 expenditures in Northeast Ohio, excluding household spending. Two more sectors, information and telecommunication and utilities, each accounted for over 5% of total expenditures.

Businesses deriving the most benefit from spending by NASA Glenn personnel and other workers whose earnings are due in part to NASA Glenn's expenditures followed typical consumer spending patterns. These included businesses in the following industries: food services, real estate companies, hospitals and healthcare services, motor vehicle dealers, accounting services, commercial banks, and miscellaneous retailers.

D.3. ECONOMIC IMPACT ON THE STATE OF OHIO, FY 2011

In this section, we present the economic impact of NASA Glenn on the Ohio economy in FY 2011. The economic impact is presented through a detailed analysis of the change in output (sales), employment, labor income (household earning), value added, and taxes due to NASA Glenn's activities in Ohio. This section follows the structure of Section D.2., Economic Impact on Northeast Ohio, FY 2011.

D.3.1. Output Impact on the State of Ohio, FY 2011

The economic impact analysis uses multipliers to estimate the ripple effect that an initial expenditure has on a studied economy. These multipliers measure the effect of NASA Glenn's spending on output (sales) across the state of Ohio. The multipliers applied to spending in Ohio are generally larger than those applied to expenditures in Northeast Ohio because a larger geographic area allows for the capture of more purchases within the region, which, in turn, enables less leakage from the economy. As the analyzed geographic area increases in size, the amount of goods and services purchased from outside that area decreases.

NASA Glenn's expenditures were divided into two categories: (1) spending on goods and services purchased from companies and other institutions located in the state of Ohio (local) and (2) spending on goods and services from businesses located elsewhere. Local spending was then categorized by industry, based upon the IMPLAN industry classification system. Table A.4. in Appendix A provides a detailed list of NASA Glenn's expenditures by industry.

Table 11 presents the total output impact and its components. Local NASA Glenn expenditures represented the direct output impact. Indirect impact was estimated by summing the contributions of individual industries that provided inputs to the producers of goods and services ultimately consumed by NASA Glenn. Induced impact was estimated by measuring the spending of workers who were employed as a result of the increased demand for products and services created by NASA Glenn. Total output impact is the sum of change in final demand, direct impact, indirect impact, and induced impact. Table 11 reports output impacts by industry sector, illustrating how NASA Glenn's spending across Ohio affects all sectors of the state economy.

Table 11. Output Impact Based on NASA Glenn Spending in the State of Ohio, FY 2011

NASA Glenn Expenditures in Ohio: $536,557,063

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$288,355	$1,302,101	$1,590,456
Mining	$0	$683,761	$510,011	$1,193,771
Utilities	$12,774,918	$1,927,070	$7,215,475	$21,917,464
Construction	$31,946,158	$4,708,702	$2,824,172	$39,479,033
Manufacturing	$2,173,131	$7,837,559	$25,199,105	$35,209,795
Wholesale Trade	$365,890	$2,292,924	$18,680,437	$21,339,251
Retail Trade	$1,029,898	$1,229,059	$46,379,311	$48,638,268
Transportation & Warehousing	$15,554	$4,845,590	$9,468,146	$14,329,291
Information	$13,168,934	$8,312,858	$14,684,051	$36,165,842
Finance & Insurance	$0	$12,177,492	$60,530,084	$72,707,576
Real Estate & Rental	$348,755	$8,287,882	$74,469,854	$83,106,491
Professional - Scientific & Technical Svcs	$190,994,184	$21,122,565	$15,311,750	$227,428,499
Management of Companies	$0	$2,645,832	$3,863,810	$6,509,642
Administrative & Waste Services	$51,019,270	$14,965,653	$10,155,730	$76,140,653
Educational Services	$5,888,446	$42,047	$7,057,524	$12,988,017
Health & Social Services	$1,349,433	$54,804	$67,414,635	$68,818,872
Arts - Entertainment & Recreation	$335,558	$528,128	$5,318,768	$6,182,454
Accommodation & Food Services	$32,433	$3,296,482	$22,286,146	$25,615,061
Other Services	$0	$3,851,787	$20,543,395	$24,395,181
Government & Non-NAICs	$10,960	$2,365,382	$10,024,165	$12,400,507
TOTAL	**$311,453,523**	**$101,463,932**	**$423,238,670**	**$836,156,126**
Change in Final Demand	$495,339,907			
Direct Impact	$311,453,523			
Indirect Impact	$101,463,932			
Induced Impact	$423,238,670			
Total Output Impact	**$1,331,496,033**			

Notes:
For output impact, the change in final demand equals the spending by NASA Glenn within and outside Ohio, excluding wages and benefits.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

The total output impact across the state of Ohio of NASA Glenn's spending on goods and services was $1.331 billion in FY 2011. NASA Glenn's expenditures of $541.8 million resulted in an increase in output (sales) of $836.2 million across all industry sectors (Table 11). For example, NASA Glenn's spending affected a $227.4 million increase in sales (direct, indirect, and induced impacts) in professional, scientific, and technical services, and a $83.1 million increase in sales in the real estate sector.

Of the total output impact, 37.2% ($495.3 million) was accounted for by the change in final demand that occurred because NASA Glenn's activities bring resources into Ohio from outside the state. Approximately $311.5 million (23.4%) of the total output impact was a result of direct spending by NASA Glenn on goods and services purchased within the state of Ohio. The remaining output impact of $524.7 million (39.4%) was due to the indirect and induced components as NASA Glenn's spending rippled through the state economy.

An analysis of the IMPLAN model shows that the $836.2 million increase in sales generated by the direct, indirect, and induced impacts can be divided into the same broad categories that were identified for Northeast Ohio: NASA Glenn-driven industries ($414.1 million, 49.5%), consumer-driven industries ($329.5 million, 39.4%), and other industries ($92.6 million, 11.1%).[23]

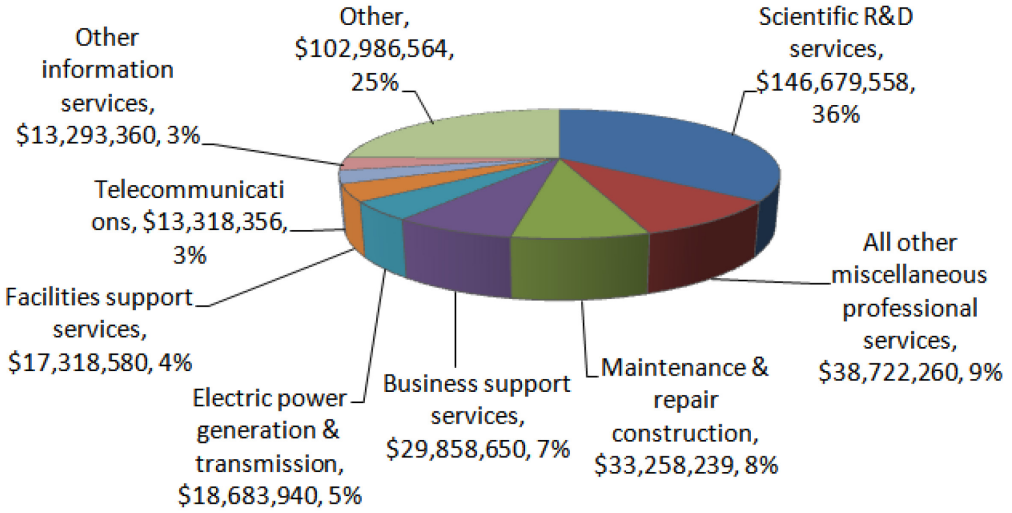
The output distribution for select NASA Glenn-driven industries is shown in Figure 13. The output distribution for select consumer-driven industries is shown in Figure 14. The select industries shown in Figures 13 and 14 each added over $13 million and $10 million, respectively.

The electric power generation and transmission industry in the state of Ohio saw an increase in revenue of $18.7 million in FY 2011 (Figure 13). This amount is the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending. This increase of $18.7 million accounted for a 5% share of the $414.1 million increase in output value for all NASA Glenn-driven industries.

Insurance carriers (finance and insurance sector) experienced a sales increase of $16.5 million in FY 2011 (Figure 14). This amount is the summation of the direct, indirect, and induced impact components generated primarily by NASA Glenn employees and other workers for insurance products. This increase of $16.5 million represented a 5% share of the $329.5 million increase in output for all consumer-driven industries.

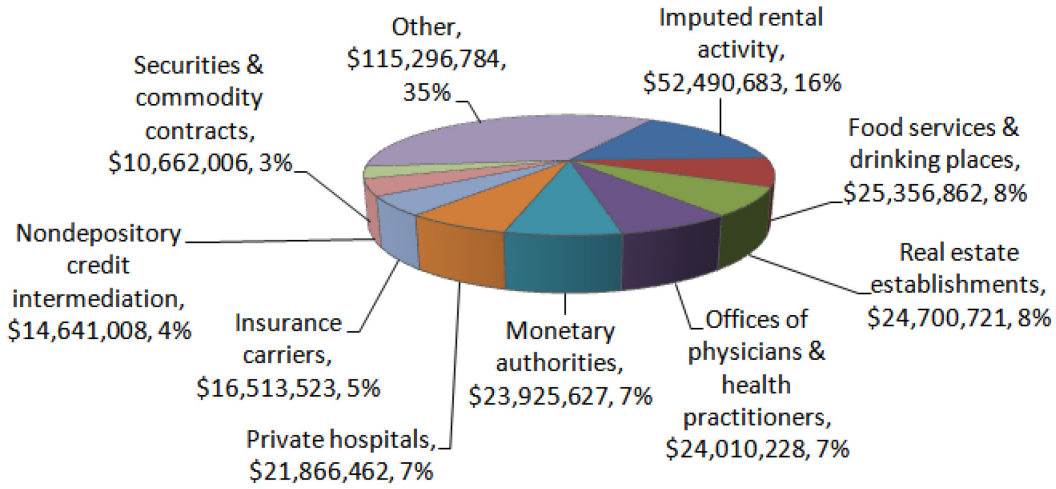
[23] NASA Glenn-driven sectors include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven sectors include retail, finance and insurance, real estate, health care, entertainment and food, other services, and owner-occupied buildings.

Figure 13. Increase in Sales for Select NASA Glenn-Driven Industries in Ohio, FY 2011



Total: $414.1 million

Figure 14. Increase in Sales for Select Consumer-Driven Industries in Ohio, FY 2011



Total: 329.5 million

D.3.2. Employment Impact on the State of Ohio, FY 2011

NASA Glenn's activities affected job creation beyond its own hiring of employees (change in final demand). NASA Glenn's spending created employment across the state of Ohio in the supply-chain industries from which it purchases goods and services (direct impact), and in industries that provide inputs into those goods and services (indirect impact).

In addition, money spent by NASA Glenn employees and employees of supply companies created jobs in a variety of other industries (induced impact). The total employment impact equals the sum of NASA Glenn's full-time equivalent (FTE) employment and the direct, indirect, and induced components. Table 12 shows the number of jobs created by industry sector.

Table 12. Employment Impact Based on NASA Glenn Spending in the State of Ohio, FY 2011

NASA Glenn Expenditures in Ohio: $536,557,063

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	0	4	13	18
Mining	0	3	4	7
Utilities	25	3	13	42
Construction	317	42	29	387
Manufacturing	9	24	52	85
Wholesale Trade	2	15	121	138
Retail trade	57	20	792	869
Transportation & Warehousing	0	42	82	124
Information	75	29	54	158
Finance & Insurance	0	57	318	376
Real Estate & Rental	1	59	185	245
Professional - Scientific & Technical Services	1,341	180	140	1,661
Management of Companies	0	14	20	34
Administrative & Waste Services	909	280	180	1,369
Educational Services	78	1	120	199
Health & Social Services	12	0	757	770
Arts - Entertainment & Recreation	4	12	110	126
Accommodation & Food Services	1	66	445	512
Other Services	0	44	322	365
Government & Non-NAICs	0	16	51	67
TOTAL	**2,832**	**911**	**3,807**	**7,550**
Change in Final Demand	1,711			
Direct Impact	2,832			
Indirect Impact	911			
Induced Impact	3,807			
Total Employment Impact	**9,261**			

Notes:
For employment impact, the change in final demand equals the number of full-time equivalents (FTEs) employees working for NASA Glenn.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

Employment increased by 9,261 jobs in Ohio in FY 2011 because of NASA Glenn's presence in the state. Of these jobs, 1,711 people (18.5%) were directly employed at NASA Glenn. As a result of NASA Glenn's direct spending for goods and services purchased in Ohio, 2,832 jobs (30.6%) were created. The remaining employment impact—4,718 jobs (50.9%)—was in the form of indirect and induced impacts as NASA Glenn's spending rippled through the state economy.

Of the 7,550 jobs created in Ohio due to the direct, indirect, and induced components, 3,819 (50.6%) were found in NASA Glenn-driven sectors, 3,262 (43.2%) were in consumer-driven sectors, and 469 (6.2%) fell under the category of other sectors.[24]

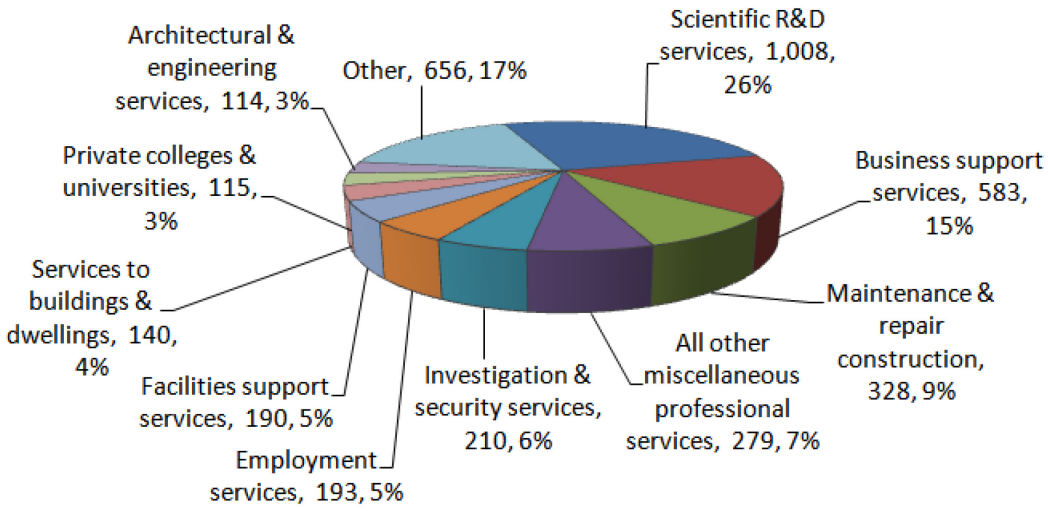
The job distribution for select NASA Glenn-driven industries is shown in Figure 15. The job distribution for select consumer-driven industries is shown in Figure 16. The select industries shown in Figures 15 and 16 each added over 100 jobs.

Because of NASA Glenn's spending in the state of Ohio, 583 jobs were added in business support services during FY 2011 (Figure 15). These jobs are the summation of the direct, indirect, and induced employment impacts generated primarily, but not exclusively, by NASA Glenn's need for business support services. The 583 jobs accounted for a 15% share of the 3,819 jobs that were created in all NASA Glenn-driven industries.

The general merchandise retail stores industry experienced an increase of 149 jobs in FY 2011 (Figure 16). These jobs are the summation of the direct, indirect, and induced components generated primarily by NASA Glenn employees and other workers who shopped at retail stores. The 149 jobs accounted for a 5% share of the 3,262 jobs that were created in all consumer-driven industries.

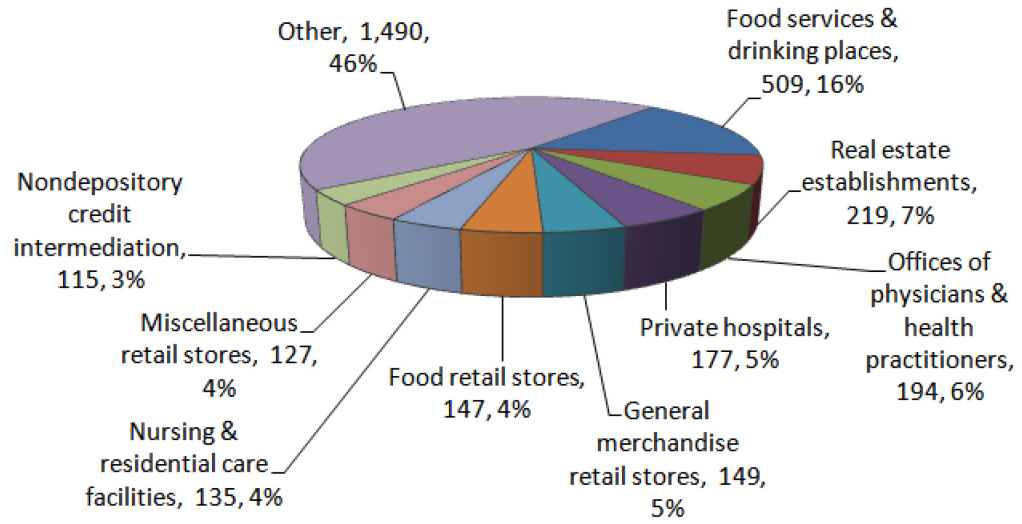
[24] Glenn-driven industries include utilities, construction, information, professional and scientific services, administrative and support services, and education. Consumer-driven industries include retail, finance and insurance, real estate, healthcare, entertainment and food, other services, and owner-occupied buildings.

Figure 15. Increase in Jobs for Select NASA Glenn-Driven Industries in Ohio, FY 2011



Total: 3,819 jobs

Figure 16. Increase in Jobs for Select Consumer-Driven Industries in Ohio, FY 2011



Total: 3,262 jobs

D.3.3 Labor Income Impact on the State of Ohio, FY 2011

Labor income (household earnings) is the estimated change in earnings received by households in the state of Ohio due to NASA Glenn's spending on goods and services within the state. Money paid to employees of companies and other suppliers of goods and services to NASA Glenn represented the direct earnings impact. Indirect impact was estimated by summing the monies paid to employees who work for companies that provide inputs to the producers of the goods and services ultimately consumed by NASA Glenn. Induced impact was generated by monies paid to workers in all industries who were employed as a result of the increased demand for products and services created by NASA Glenn. Adding the direct, indirect, and induced impacts to the wages and benefits received by NASA Glenn employees (change in final demand) results in the total earnings impact. Table 13 shows the labor income impact by industry sector.

Table 13. Labor Income Impact Based on NASA Glenn Spending in the State of Ohio, FY 2011

NASA Glenn Expenditures in Ohio: $536,557,063

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$89,688	$386,038	$475,726
Mining	$0	$199,910	$184,849	$384,759
Utilities	$2,765,051	$381,682	$1,448,188	$4,594,922
Construction	$12,933,566	$1,829,656	$1,156,856	$15,920,079
Manufacturing	$559,278	$1,491,244	$3,234,692	$5,285,214
Wholesale Trade	$144,141	$1,042,457	$8,492,893	$9,679,491
Retail Trade	$963,121	$578,068	$21,473,431	$23,014,620
Transportation & Warehousing	$7,370	$2,059,132	$4,029,201	$6,095,703
Information	$3,071,293	$1,837,549	$3,103,911	$8,012,753
Finance & Insurance	$0	$3,075,960	$16,603,477	$19,679,436
Real Estate & Rental	$91,653	$1,084,776	$3,053,157	$4,229,586
Professional - Scientific & Technical Svcs	$97,174,039	$11,571,820	$8,372,538	$117,118,397
Management of Companies	$0	$1,460,658	$2,133,056	$3,593,714
Administrative & Waste Services	$29,538,184	$8,154,957	$5,373,097	$43,066,237
Educational Services	$3,120,347	$21,811	$3,854,172	$6,996,331
Health & Social Services	$595,062	$23,742	$37,369,849	$37,988,654
Arts - Entertainment & Recreation	$106,731	$212,266	$1,996,920	$2,315,918
Accommodation & Food Services	$11,382	$1,083,621	$7,339,175	$8,434,178
Other Services	$0	$1,760,879	$9,418,503	$11,179,382
Government & Non-NAICs	$2,746	$1,174,634	$3,563,608	$4,740,988
TOTAL	**$151,083,965**	**$39,134,511**	**$142,587,612**	**$332,806,088**
Change in Final Demand	$223,804,425			
Direct Impact	$151,083,965			
Indirect Impact	$39,134,511			
Induced Impact	$142,587,612			
Total Labor Income Impact	**$556,610,513**			

Notes:
Labor income constitutes economic impact through households of NASA employees and those affected by NASA operations throughout the economy.
For labor income impact, the change in final demand equals the wages and benefits paid to NASA Glenn employees.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

Total labor income in the state of Ohio increased by $556.6 million as a result of NASA Glenn's spending on goods and services in FY 2011. Of this amount, $223.8 million (40.2%) was the wages and benefits paid to NASA Glenn employees (change in final demand). Monies paid to employees of companies across the state that supplied goods and services to NASA Glenn (direct impact) represented $151.1 million (27.2%). The remaining earnings impact (indirect and induced components), estimated to be $181.7 million (32.6%), occurred as a result of NASA Glenn's spending rippling through the Ohio economy.

Of the $332.8 million increase in household earnings attributed to the direct, indirect, and induced impacts, $195.7 million (58.8%) was reported in Glenn-driven industries, $106.8 million (32.1%) occurred in consumer-driven industries, and $30.3 million (9.1%) was reported in other industries.[25]

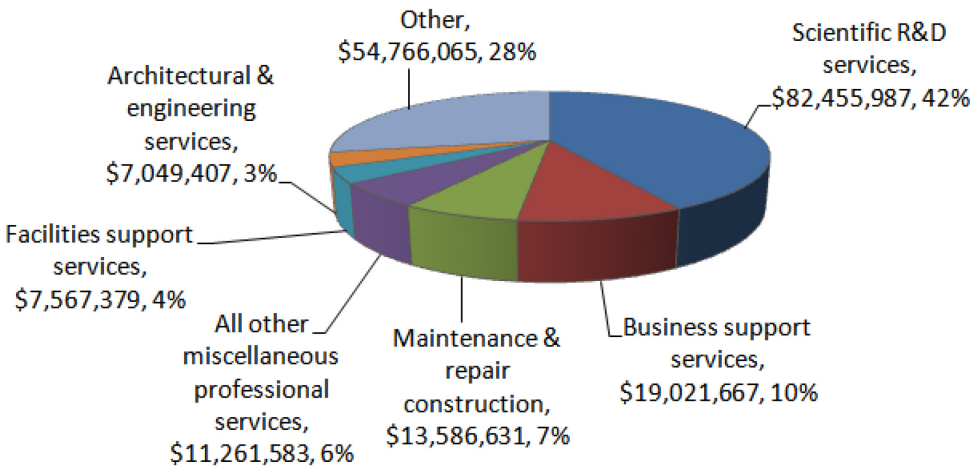
The household-earnings distribution for select NASA Glenn-driven industries is shown in Figure 17. The household earnings distribution for select consumer-driven industries is shown in Figure 18. The selected industries shown in these figures experienced the most gains in earnings (over $7 million each in Figure 17 and over $3 million each in Figure 18).

Within the NASA Glenn-driven industries, employees in architectural and engineering services across the state of Ohio saw their household earnings increase by $7 million in FY 2011 (Figure 17). These earnings are the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn's purchases of architectural and engineering services. The $7 million represented a 3% share of the $195.7 million earnings increase that occurred in all NASA Glenn-driven industries.

Within the consumer-driven industries, persons working for motor vehicle and parts dealers (retail trade sector) experienced an increase in household earnings of $4 million in FY 2011 (Figure 18). This amount is the summation of the direct, indirect, and induced impacts generated primarily by the spending of NASA Glenn employees and other workers on automobiles and other types of motor vehicles. The $4 million accounted for a 4% share of the $106.8 million earnings increase that was reported by all consumer-driven industries.

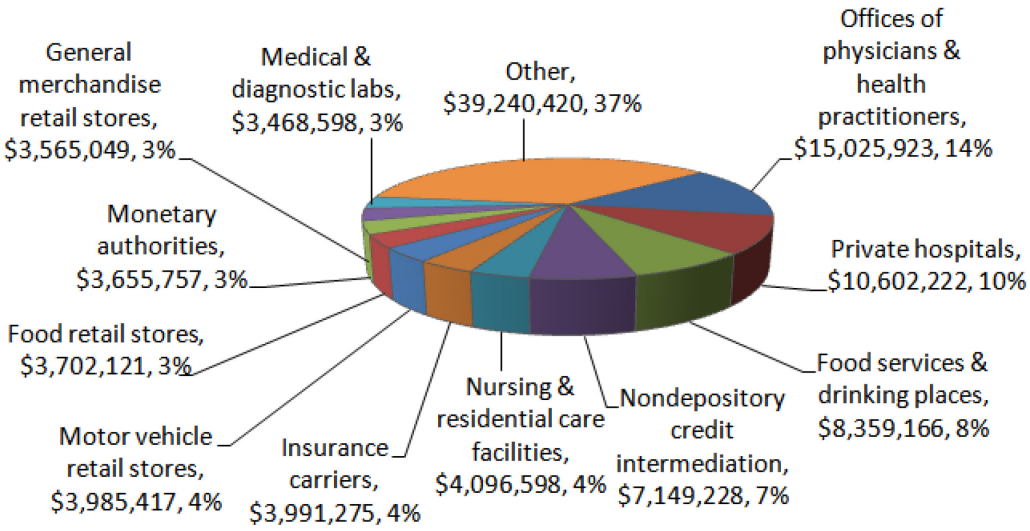
[25] See section D.2.1. Output Impact on Northeast Ohio, FY 2011 for detailed definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 17. Increase in Earnings for Select NASA Glenn-Driven Industries in Ohio, FY 2011



Total: $195.7 million

Figure 18. Increase in Earnings for Select Consumer-Driven Industries in Ohio, FY 2011



Total: 106.8 million

D.3.4. Value-Added Impact on the State of Ohio, FY 2011

NASA Glenn's spending affected an increase of $737.7 million in value added for all industries.[26] The wages and benefits received by NASA Glenn employees constituted the change in final demand for value added. Sales (less intermediary goods and services) of companies and other entities who supply goods and services to NASA Glenn represented the direct value-added impact. Indirect impact was estimated by summing the sales of companies that provide inputs to the producers of goods and services ultimately consumed by NASA Glenn (excluding the value of intermediary goods and services). Induced impact represented sales, excluding intermediary goods and services, in all industries that produced products for households whose income is affected by the demand for products and services created by NASA Glenn. The total value-added impact is a summation of the direct, indirect, and induced impacts and the wages and benefits received by NASA Glenn employees (change in final demand) (Table 14).

[26] Value added measures the economic impact of all goods and services produced in the state of Ohio due to NASA Glenn's operation (excluding intermediary goods).

Table 14. Value-Added Impact Based on NASA Glenn Spending in the State of Ohio, FY 2011

NASA Glenn Expenditures in Ohio: $536,557,063

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing & Hunting	$0	$125,942	$555,623	$681,565
Mining	$0	$439,956	$344,665	$784,621
Utilities	$10,638,656	$1,442,410	$5,441,211	$17,522,277
Construction	$15,584,482	$2,193,797	$1,388,015	$19,166,294
Manufacturing	$818,336	$2,495,283	$6,403,203	$9,716,821
Wholesale Trade	$255,938	$1,850,996	$15,080,053	$17,186,987
Retail Trade	$1,471,792	$809,552	$30,798,245	$33,079,589
Transportation & Warehousing	$9,264	$2,862,398	$5,535,303	$8,406,964
Information	$10,660,994	$4,301,156	$7,782,181	$22,744,331
Finance & Insurance	$0	$5,990,896	$29,985,277	$35,976,173
Real Estate & Rental	$186,595	$6,785,476	$62,904,887	$69,876,958
Professional - Scientific & Technical Svcs	$120,097,723	$14,853,206	$11,193,663	$146,144,593
Management of Companies	$0	$1,675,913	$2,447,400	$4,123,313
Administrative & Waste Services	$32,325,541	$9,456,828	$6,414,562	$48,196,931
Educational Services	$3,197,020	$21,586	$3,475,637	$6,694,243
Health & Social Services	$736,301	$29,054	$40,298,196	$41,063,551
Arts - Entertainment & Recreation	$194,636	$266,636	$2,923,250	$3,384,522
Accommodation & Food Services	$17,729	$1,694,330	$11,447,550	$13,159,608
Other Services	$0	$2,012,003	$9,929,058	$11,941,061
Government & Non-NAICs	$2,265	$1,039,361	$3,006,495	$4,048,121
TOTAL	**$196,197,271**	**$60,346,779**	**$257,354,473**	**$513,898,523**
Change in Final Demand	$223,804,425			
Direct Impact	$196,197,271			
Indirect Impact	$60,346,779			
Induced Impact	$257,354,473			
Total Value-Added Impact	**$737,702,948**			

Notes:

For value-added impact, the change in final demand equals the wage and benefits paid to NASA Glenn employees.
Due to rounding, the total column does not equal the summation of the direct, indirect, and induced columns.

Total value added in the state of Ohio increased by $737.7 million as a result of NASA Glenn's spending on goods and services in FY 2011. Of this total amount, $223.8 million (30.3%) was the wages and benefits paid directly to NASA Glenn employees (change in final demand). Another $196.2 million (26.6%) represented the value of goods and services (less intermediary goods) companies in Ohio to NASA Glenn (direct impact). The remaining value-added impact (indirect and induced components), estimated to be $317.7 million (43.1%), occurred as the effects of NASA Glenn's spending rippled through the Ohio economy.

Of the $513.9 million increase in value added generated across Ohio due to the direct, indirect, and induced impacts, $260.5 million (50.7%) was reported in NASA Glenn-driven industries, $208.5 (40.6%) was generated in consumer-driven industries, and $44.9 million (8.7%) was reported in other industries.[27]

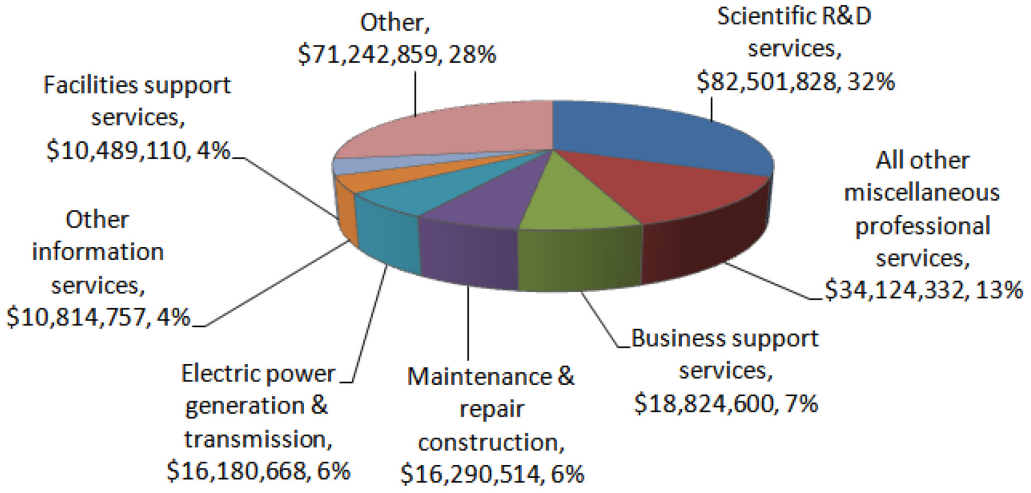
The value-added distribution for select NASA Glenn-driven industries is shown in Figure 19. The value-added distribution for select consumer-driven industries is shown in Figure 20. Selected industries in Figure 19 and Figure 20 each added over $10 and $7 million, respectively.

Within the NASA Glenn-driven industries, persons engaged in information services saw the sector's value added increase by $10.8 million in FY 2011 (Figure 19). This increase is a result of the summation of the direct, indirect, and induced impacts generated primarily, but not exclusively, by NASA Glenn's spending on information services. The $10.8 million accounted for 4% of the $260.5 million value-added increase that was reported by all NASA Glenn-driven industries.

Within the consumer-driven industries, persons working for monetary authorities saw the industry's value added increase by $10.6 million in FY 2011 (Figure 20). This increase is a result of the summation of the direct, indirect, and induced impacts generated by consumer spending on monetary authorities. The increase of $10.6 million accounted for 5% of the $208.5 million value-added increase that occurred in all consumer-driven industries.

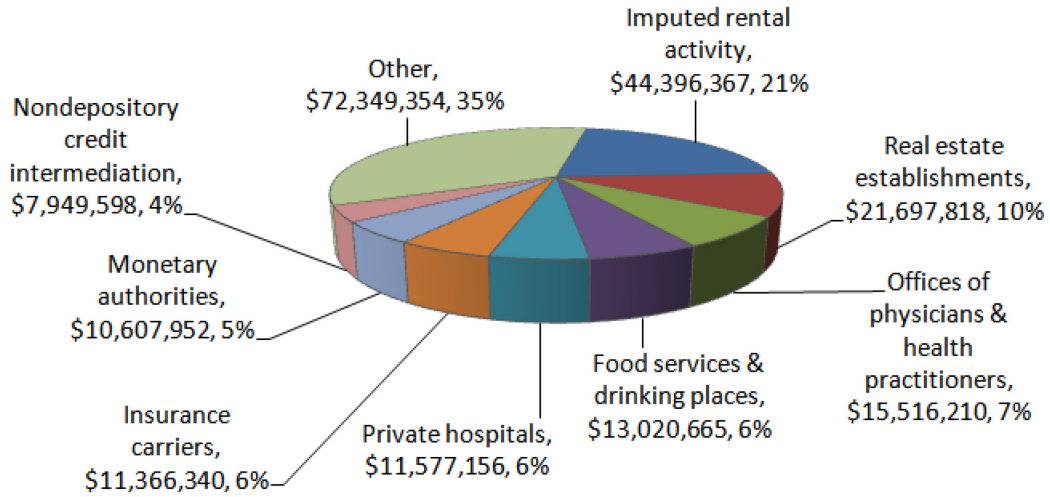
[27] See section D.2.1 Output Impact on Northeast Ohio, FY 2011 for definitions of NASA Glenn-driven, consumer-driven, and other industries.

Figure 19. Increase in Value Added for NASA Glenn-Driven Industries in the State of Ohio, FY 2011



Total: $260.5 million

Figure 20. Increase in Value Added for Consumer-Driven Industries in the State of Ohio, FY 2011



Total: $208.5 million

D.3.5. Tax Impact on the State of Ohio, FY 2011

NASA Glenn's operation and economic impact on the state of Ohio in FY 2011 increased tax revenues by a total of $110.1 million. Of that total, state and local governments in Ohio benefited from increased tax revenues of $42.0 million, and federal tax revenues increased by $68.1 million.

D.3.6. FY 2011 Ohio Impact Summary

The economic activity of NASA Glenn generated the following impact on the state of Ohio (adjusted to 2011 dollars):

- Total Output Impact: $1,331.5 M
- Total Employment Impact: 9,261 jobs
- Total Labor Income Impact: $556.6 M
- Total Value-Added Impact: $737.7 M
- Total Tax Impact: $110.1 M

The impact of NASA Glenn's expenditures on the state of Ohio is only slightly higher than the impact on Northeast Ohio. This is because the majority of NASA Glenn's expenditures in Ohio were spent in Northeast Ohio. In FY 2011, NASA Glenn's expenditures in the state of Ohio were $536.6 billion (only $89.5 million more than in Northeast Ohio).

Compared to FY 2010, in FY 2011, NASA Glenn spent more on construction and government enterprise. At the same time, expenditures for utilities; transportation; manufacturing; information and telecommunication; professional, scientific, and technical services; and education were less in FY 2011 than in FY 2010, after accounting for inflation.

More than 94% of NASA Glenn's Ohio spending, excluding household spending ($223.8 million), went to the state's five largest industry sectors: professional, scientific and technical services ($191 million); administrative and support services ($51 million); construction ($32 million); information and telecommunication ($13.2 million), and utilities ($12.8 million).

Since NASA Glenn's statewide expenditures mirrored those spent in Northeast Ohio, the industries across Ohio that derived the most benefit from NASA Glenn's spending and the spending of NASA Glenn employees and other workers were similar to those reported for Northeast Ohio.[28]

[28] A close examination of the IMPLAN results show that a few industry sectors have slightly higher values for the direct impact for Northeast Ohio than for the state of Ohio. The reason for this is the distribution of disposable income (NASA Glenn payroll) by IMPLAN to those industries from which households typically make purchases. When making this distribution for the state of Ohio, IMPLAN assumes that households have the same distribution as the population across the state. Persons living in the Appalachian area of southeast Ohio or the farming regions of western Ohio do not have the same spending patterns as their counterparts in Greater Cleveland. For example, persons living in Appalachia do not spend as much on the arts and financial services as people living in suburban Cleveland. The IMPLAN results simply reflect this reality.

E. Comparison of NASA Glenn Economic Impacts in FY 2010 and FY 2011

NASA Glenn continues to be an important economic player in Northeast Ohio and across the state (Table 15). The economic impact in FY 2011 was comparable in all measures to the economic impact in FY 2010. NASA Glenn generated 9,261 jobs in **Ohio** in FY 2011, compared to 8,868 in the previous year (a 4.4% increase). Output impact on the state was $1.332 billion in FY 2011, compared to $1.405 billion in FY 2010 after accounting for inflation (5.2% lower in FY 2011). Labor income was $24.2 million higher in FY 2011 as a result of NASA Glenn's activities (4.5% higher than in the previous year). In FY 2011, value-added impact was $737.7 million, compared to $698.3 million in FY 2010 (a 5.6% increase). Federal, state, and local taxes amounted to $110.1 million in FY 2011, up from $105.4 million in FY 2010.

In **Northeast Ohio**, NASA Glenn's output impact in FY 2011 was $1.192 billion, compared to $1.283 billion in FY 2010 (after accounting for inflation). NASA Glenn generated 7,819 jobs in Northeast Ohio in FY 2011, compared to 7,680 jobs in FY 2010 (a 1.8% increase). In addition, the labor income impact in Northeast Ohio in FY 2011 was higher than in FY 2010 by $25.3 million (a 5.3% increase). Value added (output less intermediary goods and services) in Northeast Ohio increased in FY 2011 to $666.1 million, compared to $630.1 million in FY 2010 (a 5.7% increase). Due to NASA Glenn's operations in FY 2011, taxes generated in Northeast Ohio at all levels added up to $94.2 million, compared to $90.2 million in FY 2010.

NASA Glenn continues to be one of the major economic anchors of Northeast Ohio, as evidenced by its large economic impact on the regional and state economies. Further, NASA Glenn is a crucial part of the region's intellectual infrastructure. It is an important asset for building innovative clusters in Northeast Ohio, especially at a time of manufacturing renaissance and potential growth in Ohio due to Utica Shale development. NASA Glenn's employees are part of the region's knowledge-intensive labor force and have unique cutting-edge skills in science and technology potentially capable of generating wealth in the region.

Table 15. NASA Glenn Economic Impact, FY 2010-FY 2011[29]

Economic Impact	Northeast Ohio		State of Ohio	
	FY 2010	FY 2011	FY 2010	FY 2011
Output	$1,282.6 million	$1,192.0 million	$1,404.7 million	$1,331.5 million
Value Added	$630.1 million	$666.1 million	$698.3 million	$737.7 million
Employment	7,680 jobs	7,819 jobs	8,868 jobs	9,261 jobs
Labor Income	$478.7 million	$504.0 million	$532.4 million	$556.6 million
Taxes	$90.2 million	$94.2 million	$105.4 million	$110.1 million

Note: Data are adjusted to 2011 dollars for comparison.

[29] It should be noted that NASA Glenn's annual impact is measured under the hypothetical pretense that NASA Glenn did not exist the previous year. Therefore, for example, the jobs created in Ohio in FY 2011 (9,261) are not necessarily new jobs created in addition to a previous year's jobs (8,868). The majority of FY 2011 jobs already existed in FY 2010.

APPENDIX A: DATA TABLES

Table A.1. NASA Glenn Spending by State, FY 2011

State	Spending	Share
Ohio	$312,752,638	63.14%
California	$25,491,673	5.15%
Maryland	$22,015,963	4.44%
Oklahoma	$17,743,458	3.58%
Tennessee	$16,324,091	3.30%
Connecticut	$12,738,867	2.57%
Massachusetts	$10,987,628	2.22%
Virginia	$10,033,803	2.03%
Missouri	$8,196,986	1.65%
Colorado	$7,830,454	1.58%
Texas	$5,238,814	1.06%
Pennsylvania	$5,218,786	1.05%
Florida	$4,608,557	0.93%
New Jersey	$4,184,323	0.84%
District of Columbia	$3,558,397	0.72%
Arizona	$3,299,425	0.67%
Michigan	$3,070,543	0.62%
New York	$2,919,361	0.59%
Illinois	$2,654,807	0.54%
Alabama	$1,442,556	0.29%
Washington	$1,389,944	0.28%
New Hampshire	$1,352,587	0.27%
Georgia	$1,332,462	0.27%
Indiana	$1,218,281	0.25%
Minnesota	$1,026,059	0.21%
North Carolina	$913,766	0.18%
Delaware	$903,722	0.18%
West Virginia	$863,530	0.17%
Oregon	$660,382	0.13%
Utah	$523,790	0.11%
Nevada	$410,214	0.08%
New Mexico	$403,304	0.08%

State	Spending	Share
Arkansas	$397,281	0.08%
Iowa	$360,338	0.07%
Kentucky	$357,518	0.07%
Rhode Island	$348,308	0.07%
Kansas	$326,519	0.07%
Montana	$317,766	0.06%
Wyoming	$262,635	0.05%
South Carolina	$255,055	0.05%
Wisconsin	$233,860	0.05%
Vermont	$148,434	0.03%
Idaho	$109,785	0.02%
South Dakota	$108,311	0.02%
Puerto Rico	$100,000	0.02%
Nebraska	$92,162	0.02%
Mississippi	$70,307	0.01%
Maine	$55,536	0.01%
Hawaii	$35,815	0.01%
Louisiana	$3,649	0.00%
Outside U.S.	$447,459	0.09%
Total	**$495,339,907**	**100%**

Table A.2. NASA Glenn Funding Allocated to Academic Institutions by State, FY 2011

State	Amount	Share
Maryland	$7,806,412	26.70%
Ohio	$5,854,402	20.02%
Oklahoma	$2,359,486	8.07%
California	$2,000,459	6.84%
Massachusetts	$1,654,619	5.66%
Pennsylvania	$993,423	3.40%
Texas	$940,497	3.22%
West Virginia	$856,435	2.93%
Georgia	$697,401	2.39%
New York	$663,634	2.27%
Illinois	$610,060	2.09%
Indiana	$470,110	1.61%
Kentucky	$433,051	1.48%
Oregon	$391,341	1.34%
Michigan	$380,374	1.30%
Virginia	$331,908	1.14%
Florida	$328,019	1.12%
New Jersey	$287,314	0.98%
Tennessee	$283,208	0.97%
Connecticut	$270,555	0.93%
Colorado	$241,466	0.83%
Rhode Island	$209,570	0.72%
Arizona	$166,543	0.57%
Iowa	$154,703	0.53%
Washington	$143,311	0.49%
Missouri	$113,633	0.39%
Delaware	$111,108	0.38%
Puerto Rico	$100,000	0.34%
Alabama	$92,516	0.32%
Wyoming	$88,063	0.30%
New Mexico	$80,044	0.27%
North Carolina	$54,258	0.19%
Hawaii	$35,754	0.12%
Mississippi	$32,072	0.11%
Minnesota	$2,852	0.01%
Louisiana	$61	0.00%
Total	**$29,238,661**	**100%**

Table A.3. NASA Glenn Detailed Expenditures in Northeast Ohio, FY 2011

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$12,683,154**
	Electric power generation, transmission, and distribution	31	$11,887,541
	Natural gas distribution	32	$639,209
	Water, sewage and other treatment and delivery systems	33	$156,403
Construction			**$31,935,942**
	Construction of other new nonresidential structures	36	$5,506,462
	Maintenance and repair construction of nonresidential structures	39	$26,429,480
Manufacturing			**$1,386,162**
	Carpet and rug mills	82	$5,391
	Printing	113	$3,709
	Petroleum lubricating oil and grease manufacturing	118	$143,233
	All other petroleum and coal products manufacturing	119	$180
	Industrial gas manufacturing	121	$149,109
	Paint and coating manufacturing	136	$11,016
	Glass product manufacturing made of purchased glass	159	$10,492
	Steel product manufacturing from purchased steel	171	$10,639
	Plate work and fabricated structural product manufacturing	186	$47,419
	Hardware manufacturing	193	$11,633
	Machine shops	195	$178,817
	Valve and fittings other than plumbing manufacturing	198	$142,090
	Fabricated pipe and pipe fitting manufacturing	201	$2,505
	Other fabricated metal manufacturing	202	$12,805
	Other industrial machinery manufacturing	207	$76,287
	Plastics and rubber industry machinery manufacturing	208	$19,225
	Other commercial and service industry machinery manufacturing	213	$22,620
	Metal cutting and forming machine tool manufacturing	218	$64,725
	Speed changer, industrial high-speed drive, and gear manufacturing	223	$3,790
	Other general purpose machinery manufacturing	230	$26,338
	Industrial process furnace and oven manufacturing	232	$12,055
	Bare printed circuit board manufacturing	242	$147,730
	Industrial process variable instruments manufacturing	251	$44,804
	Electricity and signal testing instruments manufacturing	253	$27,455
	Analytical laboratory instrument manufacturing	254	$420
	Irradiation apparatus manufacturing	255	$5,900

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Watch, clock, and other measuring and controlling device manufacturing	256	$47,223
	All other miscellaneous electrical equipment and component manufacturing	275	$92,461
	Other aircraft parts and auxiliary equipment manufacturing	286	$12,854
	All other miscellaneous manufacturing	317	$53,237
Wholesale & Retail Trade			**$2,119,251**
	Wholesale trade businesses	319	$287,714
	Retail - Electronics and appliances	322	$46,004
	Retail - Miscellaneous	330	$1,769,439
	Retail - Non-store	331	$16,095
Transportation			**$15,554**
	Transport by truck	335	$12,614
	Transit and ground passenger transportation	336	$2,940
Information & Telecommunication			**$12,982,537**
	Book publishers	343	$800
	Telecommunications	351	$5,260
	Other information services	353	$12,976,477
Real Estate and Rental & Leasing			**$347,745**
	Commercial and industrial machinery and equipment rental and leasing	365	$347,745
Professional, Scientific, & Technical Services			**$136,068,269**
	Legal services	367	$96,874
	Accounting, tax preparation, bookkeeping, and payroll services	368	$11,000
	Architectural, engineering, and related services	369	$3,329,413
	Other computer related services, including facilities management	373	$3,585,400
	Management, scientific, and technical consulting services	374	$204,263
	Scientific research and development services	376	$93,472,416
	All other miscellaneous professional, scientific, and technical services	380	$35,368,902
Administrative & Support and Waste Management Services			**$44,371,840**
	Facilities support services	385	$17,067,198
	Business support services	386	$27,303,306
	Other support services	389	$1,335
Education			**$2,905,389**
	Private junior colleges, colleges, universities, and professional schools	392	$2,881,745
	Other educational services	393	$23,644

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Health Care & Social Assistance			**$1,349,433**
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	$1,349,433
Arts, Entertainment & Recreation			**$335,558**
	Museums, historical sites, zoos, and parks	406	$335,558
Accommodation & food services			**$32,433**
	Food services and drinking places	413	$32,433
Household			**$220,560,816**
	Household spending (c)	10001-10009	$220,560,816
TOTAL EXPENDITURES in NEO			**$447,094,081**

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.

b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2011. Values shown in Table A-3 are limited to expenditures made in Northeast Ohio.

c. Households: Household expenditures include Glenn employees' wages and benefits.

Table A.4. NASA Glenn Detailed Expenditures in the State of Ohio, FY 2011

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
Utilities			**$12,774,918**
	Electric power generation, transmission, and distribution	31	$11,887,541
	Natural gas distribution	32	$639,209
	Water, sewage and other treatment and delivery systems	33	$248,168
Construction			**$31,946,158**
	Construction of other new nonresidential structures	36	$5,506,462
	Maintenance and repair construction of nonresidential structures	39	$26,439,696
Manufacturing			**$2,173,131**
	Carpet and rug mills	82	$5,391
	Footwear manufacturing	93	-$2,004
	Printing	113	$4,923
	Petroleum lubricating oil and grease manufacturing	118	$143,233
	All other petroleum and coal products manufacturing	119	$180
	Industrial gas manufacturing	121	$282,489
	Paint and coating manufacturing	136	$11,016
	All other chemical product and preparation manufacturing	141	$439
	Polystyrene foam product manufacturing	146	$0
	Glass product manufacturing made of purchased glass	159	$10,492
	Steel product manufacturing from purchased steel	171	$10,639
	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	178	$0
	All other forging, stamping, and sintering	181	$14,743
	Handtool manufacturing	185	$5,130
	Plate work and fabricated structural product manufacturing	186	$47,419
	Hardware manufacturing	193	$13,089
	Machine shops	195	$312,058
	Valve and fittings other than plumbing manufacturing	198	$152,809
	Plumbing fixture fitting and trim manufacturing	199	$7,835
	Fabricated pipe and pipe fitting manufacturing	201	$58,451
	Other fabricated metal manufacturing	202	$23,880
	Other industrial machinery manufacturing	207	$102,419
	Plastics and rubber industry machinery manufacturing	208	$19,225
	Other commercial and service industry machinery manufacturing	213	$22,620
	Air purification and ventilation equipment manufacturing	214	$3,937
	Metal cutting and forming machine tool manufacturing	218	$64,725

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Speed changer, industrial high-speed drive, and gear manufacturing	223	$3,790
	Air and gas compressor manufacturing	227	-$775
	Material handling equipment manufacturing	228	$0
	Other general purpose machinery manufacturing	230	$40,502
	Industrial process furnace and oven manufacturing	232	$12,055
	Electronic computer manufacturing	234	$3,280
	Bare printed circuit board manufacturing	242	$147,730
	Other electronic component manufacturing	247	$10,454
	Industrial process variable instruments manufacturing	251	$52,305
	Electricity and signal testing instruments manufacturing	253	$88,326
	Analytical laboratory instrument manufacturing	254	$73,567
	Irradiation apparatus manufacturing	255	$5,900
	Watch, clock, and other measuring and controlling device manufacturing	256	$85,335
	Wiring device manufacturing	273	$4,206
	Carbon and graphite product manufacturing	274	$35,328
	All other miscellaneous electrical equipment and component manufacturing	275	$119,706
	Other aircraft parts and auxiliary equipment manufacturing	286	$18,222
	All other transportation equipment manufacturing	294	$104,823
	Office furniture and custom architectural woodwork and millwork manufacturing[1]	301	$0
	All other miscellaneous manufacturing	317	$53,237
Wholesale & Retail Trade			**$2,694,903**
	Wholesale trade businesses	319	$365,890
	Retail - Motor vehicle and parts	320	$0
	Retail - Electronics and appliances	322	$46,004
	Retail - Building material and garden supply	323	-$7,238
	Retail - Miscellaneous	330	$2,274,152
	Retail - Nonstore	331	$16,095
Transportation			**$15,554**
	Transport by truck	335	$12,614
	Transit and ground passenger transportation	336	$2,940
Information & Telecommunication			**$13,168,934**
	Periodical publishers	342	$5,226
	Book publishers	343	$800
	Software publishers	345	$158,074

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Telecommunications	351	$28,356
	Other information services	353	$12,976,477
Real Estate and Rental & Leasing			**$348,755**
	Commercial and industrial machinery and equipment rental and leasing	365	$348,755
Professional, Scientific, & Technical Services			**$190,994,184**
	Legal services	367	$117,289
	Accounting, tax preparation, bookkeeping, and payroll services	368	$11,000
	Architectural, engineering, and related services	369	$6,039,537
	Custom computer programming services	371	$49,965
	Other computer related services, including facilities management	373	$3,585,400
	Management, scientific, and technical consulting services	374	$204,263
	Scientific research and development services	376	$145,253,067
	Advertising and related services	377	$4,000
	All other miscellaneous professional, scientific, and technical services	380	$35,729,663
Administrative & Support and Waste Management Services			**$51,019,270**
	Facilities support services	385	$17,067,326
	Business support services	386	$27,303,306
	Investigation and security services	387	$6,647,303
	Other support services	389	$1,335
Education			**$5,888,446**
	Private junior colleges, colleges, universities, and professional schools	392	$5,854,402
	Other educational services	393	$34,044
Health Care & Social Assistance			**$1,349,433**
	Medical and diagnostic labs and outpatient and other ambulatory care services	396	$1,349,433
Arts, Entertainment & Recreation			**$335,558**
	Museums, historical sites, zoos, and parks	406	$335,558
Accommodation & food services			**$32,433**
	Food services and drinking places	413	$32,433
Repair & Maintenance			**$0**
	Electronic and precision equipment repair and maintenance	416	$0
Government Enterprise			**$10,960**
	Other federal government enterprises	429	$1,600
	Other state and local government enterprises	432	$9,360
Household			**$223,804,425**

NAICS Sector	Description	IMPLAN Sector (a)	Expenditure (b)
	Household spending (c)	10001-10009	$223,804,425
TOTAL EXPENDITURES in Ohio			**$536,557,063**

a. Sector: Industry classification code used by IMPLAN. It is analogous to the North American Industry Classification System (NAICS). IMPLAN provides a cross-reference table bridging their sector numbers and NAICS codes.

b. Expenditure: Actual dollar value for a product or service spent by NASA Glenn in FY 2011. Values shown in Table A-4 are limited to expenditures made in Ohio.

c. Households: Household expenditures include Glenn employees' wages and benefits.